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The Journal follows an annual format, has a scientific nature, and specializes in Industrial Design. While it published its first issue in June 2021 in collaboration with the University of Cádiz, the journal emerged from a previous stage and project: PROYECTA56. In this earlier stage, presented at the University of Málaga in October 2013, the publication had a quarterly format and a popular science approach. The first stage remained active until 2015 and was hosted by "Centro cultural La Térmica" (Málaga), involving the participation of over 100 international industrial design professionals and being part of national and international exhibitions. For this reason, the current scientific publication maintains a minimum percentage of popular science articles, remaining true to its origins.

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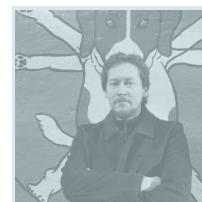
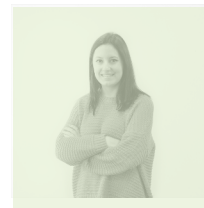
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O

n this occasion, I want to express my sincere gratitude, first and foremost, to all the distinguished authors, external reviewers, editorial board members, and collaborators for their continuous dedication and commitment to academic excellence. Their invaluable contributions have significantly enriched the content of our prestigious journal and strengthened its reputation as an unwavering source of knowledge in the field of industrial design.

I am delighted to inform you that *Proyecto56*, an Industrial Design Journal, has been duly recognized and indexed in prominent databases and repositories, further expanding our reach and visibility on a global scale. This achievement stands as a testament to the hard work and dedication of our experienced editorial team, as well as the unwavering support from our esteemed community of readers and contributors.

Likewise, it reflects the international relevance of the diverse works comprising this edition. In total, nine valuable articles from over seven countries (Germany, Argentina/Brazil, Spain, United States, Chile, Italy, and Portugal) address key topics and emerging trends in the field of industrial design. This compilation of articles encompasses innovative research, theoretical perspectives, and notable practical applications.

As is our tradition, each research article has been meticulously selected through our rigorous peer-review process to ensure undeniable quality and relevance. In this edition, we are pleased to present two outstanding research articles that masterfully link design with the environment and design education, originating from Chile and Italy respectively. From Zaragoza (Spain), we bring you a fascinating development proposing new techniques for knowledge transfer on nanomaterials from academia to industry. Additionally, the Università degli Studi della Campania offers innovative



approaches based on 5.0 technology for designing human-centered products. In line with our steadfast commitment to gender equality, Purdue University (United States) has contributed a insightful review of women's roles in the industrial design industry. Furthermore, researchers from Zaragoza explore the concept of "prosumer" as a career path for talented industrial designers.

Furthermore, in this edition, we have the honor of featuring the invaluable participation of globally renowned designer Giuseppe Bonsiepe, who has left an indelible mark on the history of design through his introduction of the concept of projective design. His distinguished academic career, teaching at the renowned Hochschule für Gestaltung (Ulum School of Design), and his work as a consultant for industrial policies in Latin America have garnered him undeniable prestige. He is joined by other distinguished guest authors, such as Matthias Laschke (University of Slegen) and Paulo Parra (University of Lisboa). In the former case, Laschke, a renowned researcher, presents a fascinating perspective titled "Friction as a Means of Choice," which explores how interactive objects can contribute to improving user habits through friction. On the other hand, Parra delves into the origins and evolution of natural inspiration and biomimetics as methods for product design, a highly relevant topic.

From the editorial board, I encourage you to carefully explore the featured articles in this edition and share your reflections and opinions with our esteemed academic community.

Sincerely,

María Alonso García

Editor of Proyecta56, an Industrial Design Journal.



Artículo de investigación | Research article

Ecodiseño como método aplicable a la didáctica del Diseño Industrial de Productos en Chile | Ecodesign as an applicable method to the didactics of Industrial Product Design in Chile

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Resumen

El siguiente artículo, asume la necesidad de aproximar la metodología y conceptos generales del ecodiseño, al ejercicio práctico del diseño de productos. Esto, a la luz de las directrices dadas por la adaptación de ciertas etapas derivadas del análisis de ciclo de vida; así como, de la identificación de oportunidades que se abren a partir de la interpretación del escenario país, ante la perentoria implementación de las distintas normativas y requerimientos que tienen por objeto la mejora ambiental.

Se propone, un modelo procedimental aplicable a la enseñanza universitaria del diseño Industrial en Chile, así como también, al desarrollo de la praxis disciplinar de nivel profesional y con especial enfoque, a la ejecutada en las pequeñas y medianas empresas. Sistematizando de este modo, aspectos decisionales para la planificación de productos con enfoque Sostenible y en sintonía con la institucionalidad ambiental vigente.

Los resultados obtenidos, evidencian una respuesta ágil en la resolución de casos dirigidos a la optimización del diseño. Considerándose para tal efecto, el lineamiento dado por el levantamiento de ciertos indicadores ambientales y su traspaso a estrategias de ecodiseño, como posibles instancias de mejora. Por lo que las soluciones propuestas, consideraron principalmente criterios de reducción y reciclabilidad de materiales, optimización y desarmabilidad eficiente de partes y componentes, así como, la extensión de la vida útil del producto. Traduciéndose estos últimos factores, en prestaciones relevantes para el usuario, por constituirse en una cercana instancia comunicativa, para la comprensión y promoción de los distintos principios que sustentan las buenas prácticas medioambientales.

Palabras clave: Diseño Industrial; Educación en Diseño; Ecodiseño; Indicador ambiental; Análisis de Ciclo de Vida; Metodología.

Abstract

The following article assumes the need to approximate the methodology and general concepts of Ecodesign to the practical exercise of Product Design. This, considering the guidelines given by the adaptation of certain stages derived from the Life Cycle Analysis; as well as the identification of opportunities that are opened from the interpretation of the country scenario, given the peremptory implementation of the different regulations and requirements that have the objective of environmental improvement.

It is proposed to establish a procedural model applicable to the University Teaching of Industrial Design in Chile, as well as the development of disciplinary praxis at a professional level and with particular focus, on the one executed in Small and Medium Enterprises. Systematizing in this way, decisional aspects for the planning of products with a sustainable approach and in tune with the current environmental institutional framework.

The results obtained show an agile response in the resolution of cases aimed at design optimization. Considering for this purpose, the guidelines given by collecting data of certain environmental indicators and their transfer to Ecodesign strategies, as possible instances of improvement. Therefore, the proposed solutions mainly considered criteria for the reduction and recyclability of materials, optimization and efficient disassembly of parts and components, as well as the extension of the useful life of the product. Translating these factors, into relevant benefits for the user, for constituting a close communicative instance, for the understanding and promotion of the different principles that support good environmental practices.

Keywords: Industrial Design; Design Education; Ecodesign; Environmental Indicator; Life Cycle Analysis; Methodology

Introducción

El sistema económico vigente a nivel global está principalmente basado en la puesta en práctica del continuo ciclo del comprar, usar y tirar (MacArthur, F.E, 2015). Instaurándose socialmente el concepto de lo desechable como la expresión máxima del consumo, y en su postura extrema, el consumismo, contribuyendo así, al fortalecimiento y consagración de la denominada economía lineal (Piñero, 2004; Murdock, 2006). Si bien lo anterior, ha posibilitado un crecimiento y desarrollo industrial sin precedentes, esto ha sido gracias también a la indiscriminada utilización de grandes cantidades de materias primas y energía adquirida a precios bajos. Principio que es considerado como rector del paradigma extractivista, el cuál ha encontrado real éxito en su implantación, pero a su vez se ha llenado de considerables críticas por su negativo impacto en términos medioambientales y los innumerables costos a pagar en términos

sociales (Sariati, 2017; Acosta, 2016; Schaffartzik et al., 2014; Krausmann et al., 2011).

Dicho escenario, ha motivado la acción de distintos actores para poder cambiar el estado de las cosas; y es así como el diseño sostenible (DS) aparece como una estrategia proyectual alternativa, prometiendo un mayor compromiso social al poner el acento en la innovación productiva para el desarrollo, pero asumiendo a la vez, responsabilidades serias, con el estado de bienestar ambiental y colectivo (Corsini y Moultrie 2021). Por su parte el ecodiseño, según lo referido en la norma ISO 14006 (2011, 2), se presenta como la respuesta metodológica para la gestión ambiental en el diseño y el desarrollo de productos, la cual considera una participación más vigorosa y proactiva en el ciclo de vida de la producción. Tanto en la optimización de los recursos energéticos-materiales, así como en la constante protección de los diversos ecosistemas (Rousseaux et al. 2017; Brambila-Macias y Sakao 2021).

Convirtiéndola en la actualidad, en una de las principales metodologías utilizadas en los países de mayor industrialización, para poder prevenir la generación de residuos; logrando transformar la normativa establecida por la institucionalidad ambiental, en acciones eficientes y efectivas para asegurar el cumplimiento de estas, pero obteniendo, además, un beneficio directo para las empresas. Confirmando, por tanto, que la rentabilidad ambiental obtenida, es factible traducirla directamente en la disminución de costos y, por ende, ser considerada como un aporte real a la competitividad (García et al. 2020). En ese sentido, y en concordancia con un concepto de eficiencia ambiental, el análisis del ciclo de vida (ACV) de los flujos de materia y energía de un producto-proceso, surge como la principal herramienta para acceder a la optimización ambiental de toda la cadena de valor (empresa, proveedores, distribuidores y usuarios), y su planificación con miras a un DS efectivo.

La institucionalidad ambiental chilena, ha decidido dar importantes pasos en términos de sostenibilidad ambiental, así como, en las posibilidades de implantación efectiva del concepto de ecodiseño. Iniciativas como la promulgación de la denominada ley de Responsabilidad Extendida del Productor, ley REP (Ley N° 20.920, 2016), la que pretende en su contenido, el establecimiento de una política marco para la gestión de los residuos y la responsabilidad extendida que al productor le pueda corresponder. Esto, sin duda, posiciona al país en una lógica económica circular, tendiente a poder guiar finalmente, hacia un cierre del ciclo existente entre el que produce, el sistema recolector de base y evidentemente el usuario (Moraga et al., 2019; Wastling et al., 2018). No obstante, su implementación aún en desarrollo ha revelado complejidades y ha generado inquietud en los distintos sectores comprometidos. Desde, las declaradas ineficiencias institucionales para fijar metas de reciclabilidad, hasta la dificultad, asumida desde las empresas, para acceder a instrumentos de ecodiseño de simple aplicación y de un costo abordable en consideración de sus recursos.

Ralentizando, por tanto, la gestión ambiental industrial, o bien desalentando numerosas inversiones en infraestructura que permitan viabilizar finalmente la puesta en marcha de las distintas normativas (Navech, 2020; Sánchez, 2021).

Considerando lo anterior, las perspectivas que se abren para la sostenibilidad ambiental, el ecodiseño y su presencia en la educación superior se vuelve auspiciosa si se compara con el resto de América Latina (Mac-Lean et al. 2020). Por lo que el rol que le cabe a la enseñanza del diseño en las universidades de nuestro país es de sobremanera relevante, si es que se decide seguir avanzando en políticas que tengan como finalidad las buenas prácticas medioambientales y su aplicación exitosa. Reconociéndose así, la imperiosa necesidad de generar espacios académicos destinados a favorecer el desarrollo de métodos simples y efectivos que conduzcan a una praxis formativa del concepto de DS (Perpignan et al., 2020) y su imprescindible traspaso al sector productivo nacional.

Atendiendo a dicho panorama, es necesario consignar que, si bien hay nutrida experiencia mundial respecto de metodologías y procedimientos de ecodiseño aplicadas a productos (IHOBE, 2000; Wimmer y Züst, 2001; Gertsakis, 2001; Wenzel y Alting, 1999), todavía parecieran no ser lo suficientemente ágiles para favorecer su implementación en términos proyectuales. Por lo que tal circunstancia debiera ser valorada para proceder en la formulación de mejoras relevantes, o al menos, ser considerada motivo de estudio en términos de como fomentar su aplicación regulada en el sector empresarial (Manzano, 2022). Siendo esto, un punto del todo significativo y que se pondera como de alto interés, para ser asumido en el trabajo que acá se presenta. De acuerdo a lo cual, el propósito general planteado pretende avanzar en la elaboración de un instrumento de aplicación simplificado destinado al desarrollo de productos, particularmente en el contexto de la enseñanza para el DS. Entendiéndose dicho aporte, como una instancia preliminar para el posicionamiento gradual del ecodiseño, como una potencial



Figura 1. Fases y subfases para esquema metodológico propuesto. Fuente: Elaboración propia

herramienta factible de ser implementada en el ámbito profesional, así como, en el sector productivo de nuestro país.

En atención a lo anterior, se proponen los siguientes objetivos procedimentales para poder sustentar dicho trabajo:

- Definir el procedimiento para la identificación y caracterización de producto a mejorar. Contemplando para esto, aspectos de información ambiental provenientes principalmente del trabajo de ACV, según consideraciones generales de la normativa ISO:14.040 (2006).
- Desarrollar evaluación diagnóstica según producto a optimizar, determinando posibles escenarios que fijen mejoras sucesivas desde el punto de vista medioambiental.
- Proponer estrategias de mejora a partir de ciertos indicadores ambientales, levantados en concordancia con los requerimientos normativos vigentes. Esto, como una forma de fijar lineamientos de optimización continua, factibles de ser aplicados a cada producto y/o su proceso de desarrollo.
- Indagar en soluciones de diseño a modo ensayo del procedimiento propuesto, poniendo un énfasis inicial en aquellas que propuestas que consideren el fin de vida del producto, FVP (Miranda de Souza & Borsato, 2016; Ma et al., 2018).

Metodología

El esquema metodológico propuesto, se constituye de dos fases principales para poder implementar un modelo procedimental (Figura 1).

Dichas fases (A y B), establecen de manera inicial un dominio basado en la evaluación y análisis del producto a optimizar según encargo tipo, considerando para esto, las etapas generales del método de balance propuesto por Zeng, et al (2017). Para ya en la fase posterior, definir estrategias y propuestas para la formulación de un nuevo y mejorado concepto de diseño que minimice las externalidades ambientalmente negativas. Lo anterior requiere de una aplicación progresiva que debiera contemplar necesariamente, la evaluación y mejora continua de la respuesta de diseño ejecutada, tendiente a alcanzar un virtuoso ciclo de calidad ambiental integrado al trabajo de diseño de productos (Rodríguez et al., 2017; Brones et al., 2017).

A continuación, se presentan las subfases detalladas para el modelo procedimental propuesto y las definiciones respectivas para cada una de estas:

Fase A. Evaluación

a.1. Reconocimiento y balance. Esta instancia, permite establecer una caracterización del producto mediante la generación de un conjunto de datos, con el objetivo de finalizar en una suerte de inventario sintetizado. La estructura general considera primeramente todos los datos de tipo identificatorio vale decir, el tipo de proyecto, empresa mandante, descripciones generales del producto a evaluar, responsabilidades y estados de avance del proyecto en ejecución. Para ya en una segunda parte, pasar a establecer directamente la caracterización del producto a partir de una desagregación general de la unidad en subunidades y con esto, un proceso de pesaje en gramos de cada una de ellas, en conjunto con el pesaje total del sistema en cuestión. Constituyendo esto, una relevante agrupación de datos que da el comienzo a un proceso de ACV simplificado, que es, en definitiva, la base fundamental del modelo que se presenta.

a.2. Levantamiento de Indicadores. Se resuelve una evaluación del producto para poder cuantificar su desempeño medio ambiental. Para lo cual, se estima el levantamiento de cuatro (4) indicadores principales que se derivan de toda la información recogida en el reconocimiento y balance previo. Dichos índices, se relacionan de manera directa con el FVP y se seleccionan de acuerdo a la relevancia que puedan tener para la optimización ambiental del producto. Cada uno de ellos, tienen como objetivo el describir el nivel de ajuste de un sistema, subsistema o partes de un producto (SSP) específico, en razón de estos índices. Estimándose en general, que los valores de ajuste más bajos indican una mayor proximidad al estado ideal. Por lo tanto, los niveles de ajuste más altos estarían describiendo cuestiones más críticas, que requerirán más consideración por parte del diseñador para poder establecer estrategias de optimización. Por lo que, en consecuencia, dichos indicadores se convierten en una práctica guía para disponer de una ponderación general del producto, obteniendo un

escenario diagnóstico en torno a su estado y para desde allí proceder con las posibles mejoras (de Aguiar et al., 2017). Los siguientes, son los indicadores sugeridos para el proceso:

- Indicador n°1, es el del impacto ambiental de la materia prima y este requiere para poder ser configurado una caracterización general del producto. El objetivo de esto es poder llegar a ponderar la procedencia del mismo material y su naturaleza de obtención; las posibilidades de reciclabilidad y la peligrosidad de la tipología material que compone el producto a evaluar.

- Indicador n°2, estima una evaluación del impacto ambiental a nivel del consumo de energía que compromete el uso del producto a evaluar, su relación con la potencia y esta con la variable tiempo, en términos de utilización por un determinado período.

- Indicador n° 3, se define como la evaluación funcional del producto. Este indicador establece la aplicabilidad directa del desempeño de la interfase y la valoración dada por el usuario en términos de acciones eficientes percibidas. Se hace especial énfasis en las funciones que puedan relacionarse con la gestión ambiental del producto, como por ejemplo su fin de vida, la desarmabilidad o la durabilidad entre otras.

- Indicador n° 4, establece la evaluación de la recuperabilidad; y esta, respecto de la ponderación del número de componentes presentes, el número de materiales y los sistemas de unión factibles de ser reconocidos en el sistema general del producto.

a.3. Análisis del diagnóstico actual del producto. Esta etapa establece la relación existente entre los indicadores levantados y ciertos requerimientos esperados en términos ideales. Dicho vínculo, se resuelve como la forma de entregar un diagnóstico del panorama actual que tiene el producto en evaluación, en ponderación con determinadas exigencias ambientales para

brindar un estado de las cosas y visualizar de esta manera, cuál es el espacio por recorrer para avanzar en dichas mejoras. Estos principios y reglas son asumidos desde el estudio propuesto en la Universidad de Delft por Brezet y van Hemel (1997), Países Bajos, el que plantea ocho estrategias de diseño y que son estructuradas en la denominada rueda estratégica de ecodiseño o LiDS Wheel (Life Cycle Design Strategy Wheel). Su aplicación, ha servido a diversos autores, como parámetro para fijar mediciones respecto factores relevantes en términos

Fase B. Definición y Propuestas

b.1. Objetivos y medidas de mejora de un producto. El resultado del cruce de las estrategias de ecodiseño con los indicadores levantados en las evaluaciones preliminares se procesa como un diagnóstico del producto. Dicho escenario es factible de ser representado esquemáticamente, por lo que se aplica un gráfico de tipo radial que en definitiva es el símil al desarrollado por Brezet y van Hemel (LiDS Wheel) y que sintetiza ciertas problemáticas ambientales en ocho estrategias de Wcodiseño jerarquizadas en escala de uno a diez. Reconociendo de esta forma cada uno de los promedios obtenidos, como la interpretación de los distintos espacios de mejora en los que se debiera trabajar para ir avanzando en la optimización ambiental. Se inicia así, el planteamiento preliminar de ciertas propuestas que eventualmente pudieran ir alineándose con las necesidades expresadas por el mandante y asumidas como limitantes válidas asociadas al proyecto. Lo que en concordancia con las oportunidades detectadas por la evaluación del producto, favorecerían la priorización de las ideas propuestas en razón de la viabilidad de implementación inmediata, así como también, ayudarían a visualizar áreas futuras en donde proceder con un proceso de mejora continua (Iuga et al, 2017; Brones et al, 2017).

b.2. Especificaciones para un nuevo diseño. Las debilidades evidenciadas desde el producto en análisis son el punto

de inicio para el desarrollo de nuevas alternativas de diseño que superen dichas deficiencias. No obstante, estas debieran ir acomodándose a ciertas Especificaciones de diseño de producto (EDP), las que en definitiva expresan la viabilidad de implementación y las condiciones dadas en contexto para hacerlas efectivas. En este sentido, aspectos relativos al funcionamiento del producto y la implicancia de esta variable en la optimización ambiental; o bien, especificaciones vinculadas con los factores técnicos de fabricación/montaje y como estos favorecen la minimización de las externalidades ambientales; así como también, las exigencias normativas reglamentadas y declaradas por la institucionalidad, se convierten en los elementos de juicio que contribuyen en la definición y jerarquización de determinados criterios, los que acompañarán de una manera más objetiva, el proceso de selección de propuestas conceptuales y posteriormente su desarrollo a nivel de diseño de detalles.

Las EDP planteadas, habilitan por tanto, en la formulación de ciertos criterios, los que en un número acotado van obteniendo un valor en términos porcentuales. De esta manera, cada uno de ellos se constituye con una jerarquía o peso, en cuanto a la importancia que idealmente debiera poseer el mismo, en su relación con el sistema producto.

b.3. Propuesta de nuevo concepto de diseño. Se avanza con la etapa de evaluación de cada una de las mejores propuestas conceptuales de diseño elaboradas; por lo que cada propuesta de concepto a calificar – en concordancia con los criterios ya determinados – contará con una ponderación como resultado final. Para lo anterior, se procede de la siguiente forma; a) se mide cada criterio establecido para el proyecto, dándole una nota con escalas que pueden ser relativas y en razón de las necesidades o preferencias del equipo de diseño (de 1 a 7 o de 1 a 10 por ejemplo); b) se cuantifica dicha ponderación a partir del producto del valor con la nota asignada por cada criterio de la propuesta conceptual en

cuestión (Valor % x Nota = Ponderación); c) finalmente, la suma total de todas las ponderaciones de los criterios evaluados, determinará un puntaje por alternativa conceptual de diseño que determinará el lugar obtenido, entendiéndose que, la opción que haya logrado el puntaje más alto es la que queda en lugar privilegiado para ser considerada como alternativa válida para ser desarrollada a nivel de diseño de detalle (Ulrich y Eppinger, 2009).

Resultados

A. Etapa de Evaluación.

El procedimiento previamente definido, fue materia de ensayo y aplicación en el trabajo desarrollado por cursos de pregrado de formación universitaria en Diseño Industrial; en específico, el taller de Diseño ecológico, correspondiente al séptimo semestre de la carrera de Ingeniería en Fabricación y Diseño Industrial perteneciente a la Universidad Técnica Federico Santa María, sede Viña del Mar, Chile. Por lo que dicha investigación se asume como una instancia preliminar factible de ser verificada y corregida, permitiendo de este modo – en su mejora – el escalamiento potencial a otros casos y contextos que busquen la incorporación del DS.

Los resultados se presentaron a modo de información resumida y organizada según la fase desarrollada. Iniciando el proceso, con la recogida de información necesaria para su evaluación (fase a1), mediante la elaboración de una matriz de datos acotada, que permitió consignar el balance de materiales y componentes para su posterior análisis. El trabajo, se realizó a partir del estudio de un caso en donde el requerimiento general planteado, era poder reconocer su estatus ambiental y avanzar finalmente en su mejora. Lo anterior fue aplicado a un rodado infantil de baja complejidad, de la marca chilena Roda perteneciente a la empresa Roda Corp. Spa. (Tabla 1).

Según los datos obtenidos en la ficha a1, se procedió con el levantamiento de indicadores, comenzando con los referidos

al ámbito ambiental y su relación de impacto generado por la utilización de las materias primas previamente identificadas en el producto (ficha a 2.1). Para esto, se adaptó el método propuesto por Venegas et al. (2019). Éste, método a partir de la desagregación de la unidad total (producto) en los distintos subsistemas materiales presentes, permitió la obtención de los valores porcentuales relativos al peso (en gramos) de cada tipología que compone el sistema. De esta forma, los indicadores levantados, su ponderación y los criterios considerados para tal efecto pueden apreciarse en la tabla 2.

El segundo indicador, midió el impacto ambiental versus su consumo de energía. Para esto, se relacionó al producto con su potencia nominal expresada en kilowatt (kW), las horas de uso efectivo en un período anual, la estimación prevista en términos de vida útil del producto y finalmente el cálculo para obtener la cantidad de energía consumida en una hora (kW h) a lo largo de un año y multiplicada por los años de uso o vida útil ($\text{kW} \cdot \text{h/año} \cdot \text{años de uso}$).

Para el caso del producto en cuestión y dada la naturaleza operativa/funcional del mismo, el segundo indicador no pudo ser calculado por corresponder a un rodado infantil, el cual es activado básicamente mediante energía mecánica, producto de la tracción o propulsión humana. Por lo que finalmente y de acuerdo a los criterios que se fijaron para la obtención del indicador, se aplica el puntaje más alto; lo anterior pudo ser consignado en la tabla 3 que muestra el resultado y los criterios aplicados para esto.

El Indicador nº 3, que levanta una evaluación respecto del desempeño funcional del producto, se ejecutó a partir de un despliegue de las prestaciones que componen el sistema de producto, organizándolas en sub grupos en donde se consigna cada una de las funciones que han de ser evaluadas.

Para cada una de esas prestaciones que han de ser medidas, se procedió con la fijación de escalas numéricas de modo de contar con una referencia objetiva para proceder con la calificación. En este

¹Se espera que las votaciones ejecutadas, no superen el rango dado por el valor o puntaje de jerarquización (Pj.). Lo anterior determinaría una sobre votación que llevaría a concluir que lo que se está evaluando va más allá de lo esperado para que el sistema de producto funcione de manera correcta. Por lo que se estimaría como un sobre diseño y si es que se procede con rigurosidad en el proceso, se debiera consignar como tal la evaluación final del producto, acusando espacios de mejora del sistema.

²El método que se ocupa es a partir de una adaptación de la propuesta hecha por Ulrich & Eppinger (2009) para la fase de evaluación y selección de alternativas en el método de cinco pasos para la generación y selección de conceptos. a Gupta et al. (2017); Allen et al. (2019); Duan et al. (2015) entre otros

Tabla 1. Ficha a.1. Reconocimiento y balance de producto. Fuente: Elaboración propia

		Matriz Caracterización del producto Ficha: A1		Estado de la revisión: Versión preliminar		
Objetivo y alcance evaluación del Producto (brief mandante): Avance en mejora ambiental de producto a partir de diagnóstico de inicio						
PRODUCTO: Bicicleta de aprendizaje clásica RODA			RESPONSABLES:			
		Descripción funcional: Bicicleta /rodado de madera de aprendizaje motriz etapa pre-escolar		A cargo: Jefe de proyecto Departamento: Diseño y Medio Ambiente		
		Gestión m/a: Profesional a cargo				
Familia de Productos: Si (x) No ()			Diseño y desarrollo			
Nombre de Tipología: Bicicleta de aprendizaje RODA			Profesional a cargo			
	Componente	Número	Material	Peso(grams)	Procedencia	Origen Mat.
Subsistema Marco	Cuerpo Principal	2	Madera contrachapada	1000	Chile	Virgen
Subsistema Dirección	Horquilla	1	Madera contrachapada	400	Chile	Virgen
	Manubrio	1	Madera contrachapada	200	Chile	Virgen
	Manillas	2	Elastómero coloreado	200	China	Virgen
	Eje de Giro	1	Metal Acero corriente	400	China	Reciclado
Subsistema Ruedas	Aro	2	Polímero	900	China	Virgen
	Gomas	2	Elastómero/Caucho	580	China	Reciclado
	Bujes	2	Metal Acero inoxidable	100	China	Virgen
Subsistema Asiento	SopORTE Elevación	1	Madera contrachapada	250	Chile	Virgen
	Estructura Apoyo	1	Madera contrachapada	200	Chile	Virgen
	Acolchado	1	Polímero/ textil sintético	100	China	Virgen
Subs. Vinculaciones	Pernos Ajustes	12	Metal Acero inoxidable	150	China	Virgen
	Adhesivo	1	Epoxico	20	Chile	Virgen
TOTAL				4500		

Tabla 2. Ficha a.2.1. Impacto ambiental y materia Prima. Fuente: Elaboración propia.

			Matriz Impacto Ambiental: Materia Prima Ficha: A2.1				Estado de la revisión: Versión preliminar				
Caracterización Producto			Material				Reciclabilidad		Peligrosidad		
Material	Peso(grams)	% Peso Total	Procedencia	Puntaje	Origen mat.	Puntaje	Reciclable	% reciclabilidad	Peligroso	Codigo DS 148	% peligrosidad
Madera contrachapada	2.050	45,6	Nacional	5	no renovable	1	no	14,4	no		0
Elastómero coloreado	200	4,4	Internacional	1	no renovable	1	no		no		
Metal Acero corriente	400	8,9	Internacional	1	Reciclado	10	si		no		
Polímero	900	20,0	Internacional	1	no renovable	1	no		no		
Elastómero/Caucho	580	12,9	Internacional	1	no renovable	1	no		no		
Metal Acero inoxidable	250	5,6	Internacional	1	no renovable	1	si		no		
Polímero/ textil sintético	100	2,2	Internacional	1	no renovable	1	no		no		
Epoxico	20	0,4	Internacional	1	no renovable	1	pje LiDs	1,4	pje LiDs	1	
Peso Total	4.500	100,0	subtotal	1,5		2,1					
			pje LiDs	1,8							

Criterios Material (Promedio de 2 atributos)		
Criterios Procedencia Material		
BAJO	10 pts	Si el producto consume mat. Locales/ regionales
MEDIO	5 pts	Si el producto consume mat. Nacional
ALTO	1 pto	Si el producto consume mat. Internacional Nacional
Criterios Origen Material		
BAJO	10 pts	Si el producto contiene mat. prima reciclada
MEDIO	5 pts	Si el producto contiene mat. prima renovable
ALTO	1 pto	Si el producto contiene mat. prima no renovable
Criterios Reciclabilidad		
ALTO	10 pts	80 a 100% mat. Reciclable
MEDIO	5 pts	40 a 79 %
BAJO	1 pto	0 a 39 %
Criterios Peligrosidad		
BAJO	10 pts	80 a 100% mat. Peligroso
MEDIO	5 pts	40 a 79 %
ALTO	1 pto	0 a 39 %

Tabla 3. Ficha a.2.2. Impacto ambiental y consumo de energía. Fuente: Elaboración propia

		Matriz Impacto Ambiental: Consumo Energía Ficha: A2.2			
Producto	Potencia kW	Hr uso/año	Estimación vida util (años)	Consumo Energía en uso del producto(kW x Hr/año x años de uso)	
n/a					
Criterios Magnitud de Uso de Energía					
Evaluación	Pje LiDs	Condición			
BAJO	10 pto	Si el producto consume menos de 100 kWh			
MEDIO	5 ptos	Si el producto consume menos de 100-1000 kWh			
ALTO	1 ptos	Si el producto consume más de 1000 kWh			

sentido se crea un valor o puntaje de jerarquización (PJ.), que es el que estima el grado de importancia que cada una de las funciones tiene para el sistema, teniendo una escala nominal de uno (1) a cinco (5). Siendo el 1 que expresa el más bajo de los grados de importancia, hasta el 5 que es el que estima el mayor nivel de interés de esa prestación para el sistema de producto.

En razón de lo anterior se procedió con la evaluación en específico de cada una de las funciones que componen el sistema, teniendo como escala de calificación los valores fijados previamente. Estableciendo la votación (Vot.)¹ a partir de un rango que va desde lo muy mal resuelto (1), hasta lo óptimo en cumplimiento de la prestación y su resolución en el producto, vale decir muy bien resuelto (5).

Posteriormente, se avanzó de forma cuantitativa para obtener evaluaciones en puntos porcentuales², que posteriormente se reconocen como indicadores funcionales. Para lo anterior, se agrupó en la siguiente columna, la sumatoria ideal de cada subsistema ($\sum i$) y que surge a partir de la suma de todos los valores o Pj. al cuadrado ($Pj.^2$); así mismo, en la columna N°5, se muestra a la votación real (V. Real) que es la que reúne la sumatoria real ($\sum r$) de todos los productos dados entre el Pj. establecido para cada función del subsistema y su votación correspondiente ($Pj. \times Vot.$). Ambas sumatorias son útiles para obtener el porcentaje (%) de cumplimiento de dicho subsistema, así como de cada función, aplicando para esto una operación

de proporcionalidad, el que pudo ser registrado en la columna N° 6, y que, en términos simples, representaría el grado de conformidad factible de manifestar con las prestaciones funcionales de todo el subsistema. No obstante, los anterior, también se puede consignar a modo de balance funcional general del producto su cumplimiento total (en %). Es posible relacionando las sumatorias totales ideales del producto ($\sum ti$) con las sumatorias totales reales del mismo ($\sum tr$).

Finalmente, destacadas en color (amarillo), se observa la selección de las funciones que fueron evaluadas y que de manera más directa podrían ser relacionadas con ciertos criterios ambientales que debieran considerarse para el desarrollo del proyecto. Se estima para tal efecto, asociar el 100% de rendimiento a nivel funcional con una escala de puntaje LiDS de 1 a 10, vale decir un punto es asociable a diez puntos porcentuales ($1=10\%$). Lo anterior y los indicadores levantados se pudieron consignar en la tabla 4.

El cuarto Indicador se realizó desde un análisis del producto y las facilidades de este, para poder ser desmontado y en dicho proceso ir gestionando eficientemente el acceso a sus componentes para ser recuperados mediante el reciclaje.

El análisis, levantó una calificación desde la perspectiva del FVP y en lo particular desde el diseño para el desmontaje (DfD en su sigla en Inglés); entendido como la factibilidad presente de inicio en el sistema de producto,

para evitar la separación destructiva de sus componentes. Contribuyendo así, a la minimización de desperdicios al final de su vida útil, abriendo de este modo, espacios para su recuperación futura (Abuzied et al., 2020; Chiu y Okudan, 2010).

El análisis detallado, la ponderación de los indicadores y el puntaje LiDS obtenidos, se registraron en la tabla 5.

Finalizando la primera parte de la etapa correspondiente a la evaluación del producto, se procedió a desarrollar el análisis diagnóstico respecto del estándar ambiental que este posee en la actualidad. Para lo cual, se estableció un cruce entre las ocho estrategias de ecodiseño y el promedio de los indicadores que pudieron coincidir con dichas estrategias. Dando por tanto, el puntaje LiDS como resultado a considerar, en el planteamiento de ciertos

espacios de mejora ambiental del producto en cuestión. Los datos obtenidos pueden observarse en la tabla 6.

B. Etapa de Definición y Propuestas

Asumiendo las ocho estrategias de ecodiseño, como una instancia para agrupar incertidumbres que el diseño con perspectiva ambiental debiera considerar, se resolvió la utilización de dichos antecedentes, como un insumo válido para la elaboración de nuevas propuestas de diseño (Liu y Zhao, 2020; Rungyuttapakorn y Wongwatcharapaiboon, 2020; Zhang y Li, 2019; Diago et al., 2019; Singh y Sarkar, 2019; Carey et al., 2019).

Dicho escenario se representó de forma esquemática, aplicando un gráfico de (Figura 2).

Tabla 4. Ficha a.2.3. Evaluación funcional del producto. Fuente: Elaboración propia

	Matriz Evaluación funcional producto Ficha: A2.3				
	VALOR	VOTACIÓN	V.Ideal (Pj.2)	V.Real (Pj.xVot.)	
RODAR PARA DESPLAZAR			$\Sigma i=73$	$\Sigma r=43$	subsist = 59%
Traccionar p/d	4	2	16	8	50
Equilibrar p/d	4	3	16	12	75
Detener	4	2	16	8	50
Desplazar rodando	5	3	25	15	60
DIRECCIONAR			$\Sigma i=43$	$\Sigma r=24$	subsist = 56%
Maniobrar p/d	3	1	9	3	33
Girar p/d	3	2	9	6	67
Dirigir	5	3	25	15	60
ARMAR/DESARMAR			$\Sigma i=65$	$\Sigma r=44$	subsist = 68%
Sostener p/a-d	2	1	4	2	50
Acoplar p/a	4	2	16	8	50
Asegurar armado	3	2	9	6	67
Ajustar p/a	4	3	16	12	75
Desarmar p/trasladar	4	3	16	12	75
Manipular p/a-d	2	2	4	4	100
RESISTIR ESFUERZOS			$\Sigma i=57$	$\Sigma r=39$	subsist = 68%
Fijar piezas para r/e	4	3	16	12	75
Distribuir carga para r/e	4	3	16	12	75
Resistir flexión	4	3	16	12	75
Resistir torsión	3	1	9	3	33
GESTIONAR FDVP			$\Sigma i=67$	$\Sigma r=25$	subsist = 37%
Desarmar p/desechar	3	2	9	6	67
Variar uso	5	1	25	5	20
Extender usabilidad	5	2	25	10	40
Desechar	2	1	4	2	50
Reciclar	2	1	4	2	50
			$\Sigma ti=305$	$\Sigma tr=175$	Total produc. =57%

**Pje/LiC

**Pje/LiC

**Pje/LiC

**Pje/LiC

Tabla 5. Ficha a.2.4. Evaluación recuperabilidad del producto. Fuente: Elaboración propia

		Matriz Evaluación Recuperabilidad Ficha : A2.4				
	Componente	Número	Material	Numero de Componentes	Número de Materiales	Sist. Unión
Subsistema Marco	Cuerpo principal	2	Madera contrachapada	13	9	mixta
Subsistema Dirección	Horquilla	1	Madera contrachapada			
	Manubrio	1	Madera contrachapada			
	Manillas	2	Elastómero coloreado			
	Eje de giro	1	Metal Acero corriente			
Subsistema Ruedas	Aro	2	Polímero			
	Gomas	2	Elastómero/Caucho			
	Bujes	2	Metal Acero inoxidable			
Subsistema Asiento	Soporte Elevación	1	Madera contrachapada			
	Estructura apoyo	1	Madera contrachapada			
	Acolchado	1	Polímero/ textil sintético			
Subs. Vinculaciones	Pernos ajustes	12	Metal Acero inoxidable			
	Adhesivo	1	Epoxico			
Subtotal				1	5	5
Promedio				3,7		
Pje LiDs				3,7		

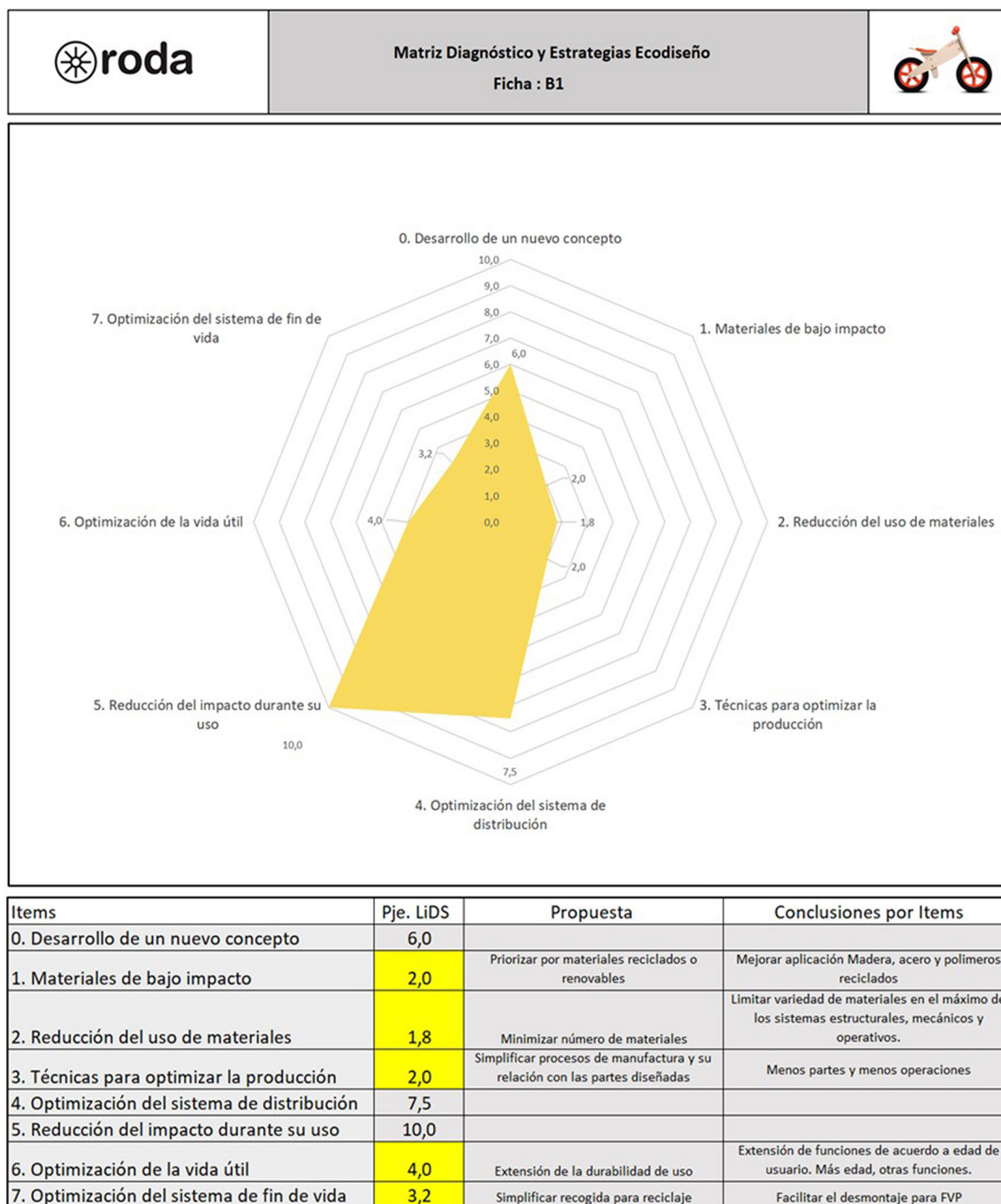
Criterios Recuperabilidad (Promedio de 3 atributos)

Numero componentes		
BAJO	10 pts	Si el producto tiene hasta 5 piezas
MEDIO	5 pts	Si el producto tiene hasta 6 a 10 piezas
ALTO	1 pts	Si el producto tiene más de 10 piezas
Numero materiales		
BAJO	10 pts	Si el producto tienes hasta 5 materiales
MEDIO	5 pts	Si el producto tiene hasta 6 a 10 materiales
ALTO	1 pts	Si el producto tiene más de 10 materiales
Sistema de unión		
BAJO	10 pts	Si el producto presenta sist. unión transitoria
MEDIO	5 pts	Si el producto presenta sist. unión mixta
ALTO	1 pts	Si el producto presenta sist. unión definitiva

Tabla 6. Ficha a.3.1. Análisis de escenarios para el ecodiseño. Fuente: Elaboración propia

	Matriz Análisis de Escenarios para el Ecodiseño Ficha : A3.1						
	IND 1			IND 2	IND 3	IND 4	LIDS
ESTRATEGIAS DE ECODISEÑO	Material	Reciclabilidad	Peligrosidad	Energía uso	Usabilidad	Recuperabilidad	Promedio
0. Desarrollo de un nuevo concepto				10,0	2,0		6,0
1. Materiales de bajo impacto	1,8	1,4	1,0			3,7	2,0
2. Reducción del uso de materiales	1,8						1,8
3. Técnicas para optimizar la producción		1,4	1,0			3,7	2,0
4. Optimización del sistema de distribución					7,5		7,5
5. Reducción del impacto durante su uso				10,0			10,0
6. Optimización de la vida útil					4,0		4,0
7. Optimización del sistema de fin de vida		1,4	1,0		6,7	3,7	3,2

Tabla 7. Ficha b.1. Diagnóstico y estrategias de ecodiseño. Fuente: Elaboración propia



tipo radial similar al desarrollado por Brezet y Van hemel (LiDS Wheel) con las ocho estrategias de ecodiseño jerarquizadas en escala de uno a diez. Así como también, una matriz resumen que consigna el puntaje LiDS obtenido y las propuestas de mejora prioritaria que se han decidido aplicar para tal efecto (tabla 7).

A partir de los resultados arrojados por la matriz B1, se establecen en una segunda instancia, las EDP que permitirán guiar

el avance del proceso de generación y evaluación de alternativas. Entendiéndose, por tanto, que las estrategias de menor puntuación son el punto de partida para la definición de los criterios a utilizar en el proceso de selección de aquellas. Los criterios derivados son los siguientes: a) Restricción variedad tipología materiales; b) Reciclabilidad y renovabilidad de materiales; c) Optimización de partes y su

Tabla 8. Ficha b.2. Selección de Propuestas de Diseño. Fuente: Elaboración propia

		Matriz de Selección de Propuestas de Diseño Ficha: B2.							
									
		Concepto (A)		Concepto (B)		Concepto (C)		Concepto (D)	
Criterios de selección	Valor (%)	Nota	Ponderación	Nota	Ponderación	Nota	Ponderación	Nota	Ponderación
Restricción variedad tipología materiales	30	5	1.5	5.5	1.65	5.5	1.65	5	1.5
Reciclabilidad y renovabilidad de materiales	25	4	1	5	1.25	5	1.25	5	1.25
Optimización de partes y su producción	15	3	0.45	5	0.75	5.8	0.87	4.5	0.675
Desarmabilidad simplificada para reciclaje	15	6	0.9	5.5	0.83	5.5	0.83	4.8	0.72
Durabilidad extendida por uso	15	5	0.75	4	0.6	5	0.75	4	0.6
Total puntos			4.6		5.1		5.4		4.7
Selección			4		2		1		3
¿Elige?			No		No		Si		No

producción; d) Desarmabilidad simplificada para reciclaje; e) Durabilidad extendida por uso.

El proceso de selección de alternativas y su ponderación por criterios, puede apreciarse en la tabla 8.

Para el caso del producto en cuestión, se pudo seleccionar un concepto acorde a los criterios y ponderaciones establecidas, lo que fue resuelto posteriormente en los siguientes diseños con sus respectivas soluciones a nivel de usabilidad y detalle

El concepto que pudo desarrollarse queda en disposición de ser prototipado, así como, de seguir siendo evaluado y optimizado, con perspectiva de mejora continua, en la medida de que el mandante decida ir integrando nuevos requerimientos para su optimización ambiental o bien, considerar nuevas regulaciones que puedan ir estableciéndose por la institucionalidad

Conclusión

- En resumen, el método propuesto permitió identificar y caracterizar un producto, considerando para esto, la necesidad de reducción futura de las externalidades medioambientales generadas por cada uno de sus componentes, la constitución de sus materiales y las características productivas. Lo anterior como el

registro de una evaluación ambiental abreviada, a partir de la selección de los aspectos de mayor relevancia y prioridad para tal efecto. Presentando así, un levantamiento esquemático de información, organizado con aquellos datos claves que constituyen y definen el sistema físico material en análisis.

Es así como, dicho instrumento se constituiría, como una herramienta válida para poder abordar proyectos de diseño de productos; ya sea, observado desde las necesidades pedagógicas exigidas, por los criterios de aprendizaje en la enseñanza de los distintos talleres proyectuales o bien, asignaturas de especialidad. Así como, en la aplicación de proyectos que demanden una resolución eficiente bajo parámetros productivos, pero con una perspectiva ambiental. Actuando, finalmente, como una guía que facilitaría la evaluación de escenarios potenciales, factibles de ser considerados en los procesos de toma de decisión para mejorar productos fabricados, pero con perspectiva sostenible.

- El procedimiento aquí presentado, constató la importancia de tener en cuenta criterios objetivos para poder avanzar correctamente con el análisis y posterior formulación de indicadores ambientales asociados a productos. Por constituirse esto, en el panorama actualizado a considerar como el inicio de una evaluación para cada caso específico a ser abordado; Procurando

así, de la necesaria planificación previa de una estructura ágil y eficiente, capaz de reaccionar ante los diversos cambios producidos en la normativa, así como, de las distintas regulaciones definidas por la institucionalidad ambiental.

- El diagnóstico inicial, incide directamente en la priorización de las estrategias de mejora ambiental utilizables para el desarrollo de nuevas propuestas de diseño de producto. Dichas medidas debieran garantizar además de los aspectos funcionales propios derivados de las necesidades prácticas y utilitarias por parte del usuario, los requisitos propios de la producción, constituidos

específicamente por los requerimientos del mandante. Permitiendo de este modo, la selección de manera dirigida y regulada de las distintas mejoras propuestas en la optimización del producto; se confirma, por tanto, la relevancia de poder contar con una evaluación objetiva y ponderada, de las diversas alternativas conceptuales que vayan surgiendo durante el proceso de diseño asumido por el equipo de desarrolladores. En este sentido, la matriz de selección (b2) pareciera ser un eficiente instrumento de evaluación, ante la exigente demanda sugerida por



Figura 2. Propuesta y diseño de detalle para producto. Fuente: Adaptación del autor a partir de Castro Y Barahona 2022.

los distintos criterios considerados en la búsqueda la solución óptima de diseño.

- La solución de diseño que pudo ejecutarse, se ajustó (en lo particular) al panorama diagnóstico levantado por la aplicación del método propuesto. Si bien, resultó complejo determinar el indicador asociado a la reciclabilidad, por vincularse a la infraestructura de reciclaje presente y actualizada en el territorio, este, se pudo abordar de manera nominal dada la naturaleza de la materia prima. Comprobándose que el instrumento planteado, es dúctil ante la necesidad de poder ensayar la definición de indicadores, a partir incluso de la debilidad presente en términos de información general. Esto, permitió constatar la flexibilidad del instrumento metodológico y las posibilidades de escalabilidad en su aplicación, lo que según lo señalado por Favi et al., (2019), debiera reflejarse tanto en proyectos formativos al interior del quehacer universitario, así como en el contexto vinculado con las necesidades de la empresa.
- Así mismo, se pudo destacar que las soluciones de diseño desarrolladas a partir de la aplicación del instrumento hacen un especial énfasis en el FVP como una estrategia de interés aplicada al producto en cuestión. Fijando su atención, preferentemente en la reciclabilidad de los residuos, el desarme y la reducción volumétrica del rodado, como una instancia destinada a facilitar la recogida y gestión final de los materiales que componen el sistema. Por lo que se concluye que este enfoque, sin ser el único que se abordó en el proyecto, favorecería la integración colectiva futura, de los principios que sustentan las buenas prácticas medioambientales (Rossi et al., 2016).
- Es necesario hacer notar que, para efecto de este trabajo, se consideró una simplificación de ciertas variables para poder ajustarse a las estrategias de ecodiseño. Tal es el caso de las normativas ambientales aplicables al fin de vida de ciertos productos (ley REP, productos prioritarios). No obstante, aquello es factible seguir perfeccionando el instrumento en términos de una cuantificación más ajustada, aun teniendo como base a la rueda de LiDS.
- La investigación desarrollada, es factible de ser potencialmente adaptada a la evaluación y análisis de tipologías o familias de productos. Lo que abre un importante espacio para poder precisar aún más, en la obtención de los indicadores ponderados. Permitiendo, un potencial cruce de información derivado de la evaluación comparativa de productos desarrollados en una empresa o bien, de un determinado sector productivo. Facilitando de este modo, la identificación y posterior solución de los distintos cuellos de botella ambiental asociables a materiales y/o procesos (Valero et al., 2018; Brundage et al., 2018).
- El trabajo expuesto, se ha constituido en un primer ensayo metodológico aplicable a la mejora de Productos desde una perspectiva ambiental. Estableciendo alrededor de los conceptos básicos de ecodiseño, procedimientos simplificados del todo factibles de ser incorporados a las fases más comunes del proceso de diseño. Se espera, por tanto, que en un breve plazo se puedan ir traspasando dichas herramientas, al ejercicio académico presente en los distintos talleres proyectuales que decidan abordar la temática del DS como desafío para sus proyectos. O bien ir prototipando – en la medida de la necesidad requerida por los mandantes – soluciones para el ejercicio profesional al interior de las empresas e ir asumiendo en conjunto con ello, el concepto de mejora continua ambiental como una forma de avanzar en el concepto de calidad asociado a la Sostenibilidad.

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Review | Revisión

Ecodesign as an applicable method to the didactics of Industrial Product Design in Chile | Ecodiseño como método aplicable a la didáctica del Diseño Industrial de Productos en Chile

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Resumen:

El siguiente artículo, asume la necesidad de aproximar la metodología y conceptos generales del Ecodiseño, al ejercicio práctico del Diseño de Productos. Esto, a la luz de las directrices dadas por la adaptación de ciertas etapas derivadas del Análisis de Ciclo de Vida; así como, de la identificación de oportunidades que se abren a partir de la interpretación del escenario país, ante la perentoria implementación de las distintas normativas y requerimientos que tienen por objeto la mejora ambiental.

Se propone, un modelo procedimental aplicable a la Enseñanza universitaria del Diseño Industrial en Chile, así como también, al desarrollo de la praxis disciplinar de nivel profesional y con especial enfoque, a la ejecutada en las Pequeñas y Medianas Empresas. Sistematizando de este modo, aspectos decisionales para la planificación de productos con enfoque Sostenible y en sintonía con la institucionalidad ambiental vigente.

Los resultados obtenidos, evidencian una respuesta ágil en la resolución de casos dirigidos a la optimización del Diseño. Considerándose para tal efecto, el lineamiento dado por el levantamiento de ciertos indicadores ambientales y su traspaso a estrategias de Ecodiseño, como posibles instancias de mejora. Por lo que las soluciones propuestas, consideraron principalmente criterios de reducción y reciclabilidad de materiales, optimización y desarmabilidad eficiente de partes y componentes, así como, la extensión de la vida útil del producto. Traduciéndose estos últimos factores, en prestaciones relevantes para el usuario, por constituirse en una cercana instancia comunicativa, para la comprensión y promoción de los distintos principios que sustentan las buenas prácticas medioambientales.

Palabras clave: Diseño Industrial; Educación en Diseño; Ecodiseño; Indicador ambiental; Análisis de Ciclo de Vida; Metodología

Abstract

The following article assumes the need to approximate the methodology and general concepts of Ecodesign to the practical exercise of Product Design. This, considering the guidelines given by the adaptation of certain stages derived from the Life Cycle Analysis; as well as the identification of opportunities that are opened from the interpretation of the country scenario, given the peremptory implementation of the different regulations and requirements that have the objective of environmental improvement.

It is proposed to establish a procedural model applicable to the University Teaching of Industrial Design in Chile, as well as the development of disciplinary praxis at a professional level and with particular focus, on the one executed in Small and Medium Enterprises. Systematizing in this way, decisional aspects for the planning of products with a sustainable approach and in tune with the current environmental institutional framework.

The results obtained show an agile response in the resolution of cases aimed at design optimization. Considering for this purpose, the guidelines given by collecting data of certain environmental indicators and their transfer to Ecodesign strategies, as possible instances of improvement. Therefore, the proposed solutions mainly considered criteria for the reduction and recyclability of materials, optimization and efficient disassembly of parts and components, as well as the extension of the useful life of the product. Translating these factors, into relevant benefits for the user, for constituting a close communicative instance, for the understanding and promotion of the different principles that support good environmental practices.

Keywords: Industrial Design; Design Education; Ecodesign; Environmental Indicator; Life Cycle Analysis; Methodology

Introduction

The current global economic system is primarily based on the “buy-use-throw away” cycle (MacArthur, F.E., 2015). The concept of disposability has been socially established as the ultimate expression of consumption – and in its extreme position, the consumerism – contributing to the consolidation of the Linear Economy (Piñero, 2004; Murdock, 2006). While this has enabled unprecedented industrial growth and development, it has also been accompanied by the indiscriminate use of large amounts of raw materials and low-cost energy. This principle is considered the guiding principle of the extractivist paradigm, which has been successful in its implementation but has faced considerable criticism for its negative environmental impact and the numerous social costs associated with it (Sariati, 2017; Acosta, 2016; Schaffartzik et al., 2014; Krausmann et al., 2011).

This context has prompted various actors to take action to change the status quo.

Sustainable Design (SD) emerges as an alternative design strategy, promising greater social commitment by emphasizing productive innovation for development while assuming serious responsibilities for environmental and collective well-being (Corsini and Moultrie 2021). Ecodesign, as referred to in ISO 14006 (2011, 2) presents itself as the methodological response to environmental management in the design and development of products. It involves a more vigorous and proactive participation in the life cycle of production, optimizing energy and material resources and consistently protecting various ecosystems (Rousseaux et al. 2017; Brambila-Macias and Sakao 2021). Currently, it is one of the main methodologies used in highly industrialized countries to prevent waste generation, transforming environmental regulations into efficient and effective actions to ensure compliance while benefiting companies directly. Thus, the environmental profitability achieved can be directly translated into

cost reduction, making it a real contribution to competitiveness (García et al. 2020). In this sense, in line with the concept of environmental efficiency, life cycle assessment (LCA) of material and energy flows in a product-process emerges as the primary tool for achieving environmental optimization throughout the value chain (company, suppliers, distributors and users), and its planning for effective SD.

The Chilean environmental institutions have taken significant steps towards environmental sustainability and the effective implementation of the concept of Ecodesign. Initiatives such as the enactments of the Extended Producer Responsibility (EPR) law (Law N° 20.920, 2016) aim to establish a framework policy for waste management and the extended responsibility of producers. This positions the country within a circular economic logic that aims to guide the cycle between producers, the base collection system, and users towards closure (Moraga et al., 2019; Wastling et al., 2018). However, its ongoing implementation has revealed complexities and raised concerns in various sectors. These range from institutional inefficiencies in setting recyclability targets to the difficulties faced by companies in accessing easily applicable and affordable Ecodesign instruments considering their resources. This has slowed down industrial environmental management or discouraged numerous investments in infrastructure necessary for the implementation of different regulations (Navech,2020; Sánchez,2021).

Chilean environmental institutions have decided to take important steps in terms of environmental sustainability, as well as in the possibilities of effective implementation of the Ecodesign concept. Initiatives such as the promulgation of the Extended Producer Responsibility, law EPR (Law N° 20.920, 2016), which intends in its content, the establishment of a framework policy for waste management and extended responsibility that may correspond to the producer. Undoubtedly, this positions the country in a circular economic logic, tending to be able to finally guide, towards a closure of the existing cycle between the one who produces, the base collection

system and obviously the user (Moraga et al., 2019; Wastling et al., 2018). However, its implementation still under development has revealed complexities and has generated concern in the different sectors involved. From the declared institutional inefficiencies to set recyclability goal, to the difficulty – assumed from the enterprises – to access Ecodesign instruments of simple application and an affordable cost considering their resources. Therefore, slowing down industrial environmental management, or else discouraging numerous investments in infrastructure that will finally enable the implementation of different regulations (Navech,2020; Sánchez,2021).

Given this context, the prospects for environmental sustainability, Ecodesign, and its presence in higher education are promising compared to the rest of Latin America (Mac-Lean et al. 2020). Therefore, the role of Design education in universities in our country is particularly relevant if we decide to continue advancing policies aimed at good environmental practices and their successful implementation. It is imperative to create academic spaces to promote the development of simple and effective methods that lead to formative praxis of the SD concept (Perpignan et al., 2020) and its essential transfer to the national productive sector.

Considering this situation, it is necessary to acknowledge that although there is abundant global experience regarding Ecodesign methodologies and procedures applied to products (IHOBE, 2000; Wimmer and Züst, 2001; Gertsakis, 2001; Wenzel and Alting, 1999), they still do not seem to be agile enough to facilitate their implementation in design terms. This circumstance should be considered to propose relevant improvements or at least be studied to determine how to promote regulated application in the business sector (Manzano, 2022). This is a significant point of interest that is highly relevant to the present work. Accordingly, the general purpose of this work is to advance the development of a simplified application instrument for product development, particularly in the context of SD education. This contribution

is understood as a preliminary step towards the gradual positioning of Ecodesign as a potential tool that can be implemented in the professional and national productive sectors.

Based on this context, the following procedural objectives are proposed to support this work: a) Define a procedure for identifying and characterizing a product to be improved, considering environmental information mainly derived from LCA work according to the general considerations of ISO:14.040 (2006). b) Develop a diagnostic evaluation for the product to be optimized, determining possible scenarios for successive environmental improvements. c) Propose improvement strategies based on certain environmental indicators, in line with current regulatory requirements. This will establish guidelines for continuous optimization that can be applied to each product and/or its development process. d) Explore design solutions as trial applications of the proposed procedure, with an initial focus on those that consider the end-of-life stage of the product, ELP (Miranda de Souza and Borsato, 2016; Ma et al., 2018).

Methodology

The proposed methodological framework consists of two main phases for implementing

a procedural model (Figure 1). These phases (A and B) initially establish a domain based on the evaluation and analysis of the product to be optimized according to the given assignment, considering the general stages of the balance method proposed by Zeng et al (2017). Subsequently, in the following phase, strategies and proposals are defined to formulate a new and improved Design that minimizes environmentally negative externalities. This requires a progressive application that necessarily involves the continuous evaluation and improvement of the executed design response, aiming to achieve a virtuous cycle of environmental quality integrated into the Product Design work (Rodrigues et al., 2017; Brones et al., 2017).

The detailed subphases for the proposed procedural model and their respective definitions are presented below:

Phase A. Evaluation

a.1. Recognition and balance. This stage allows establishing a characterization of the product by generating a set of data, aiming to conclude with a sort of synthesized inventory. The general structure initially considers all the identifying data, such as project type,

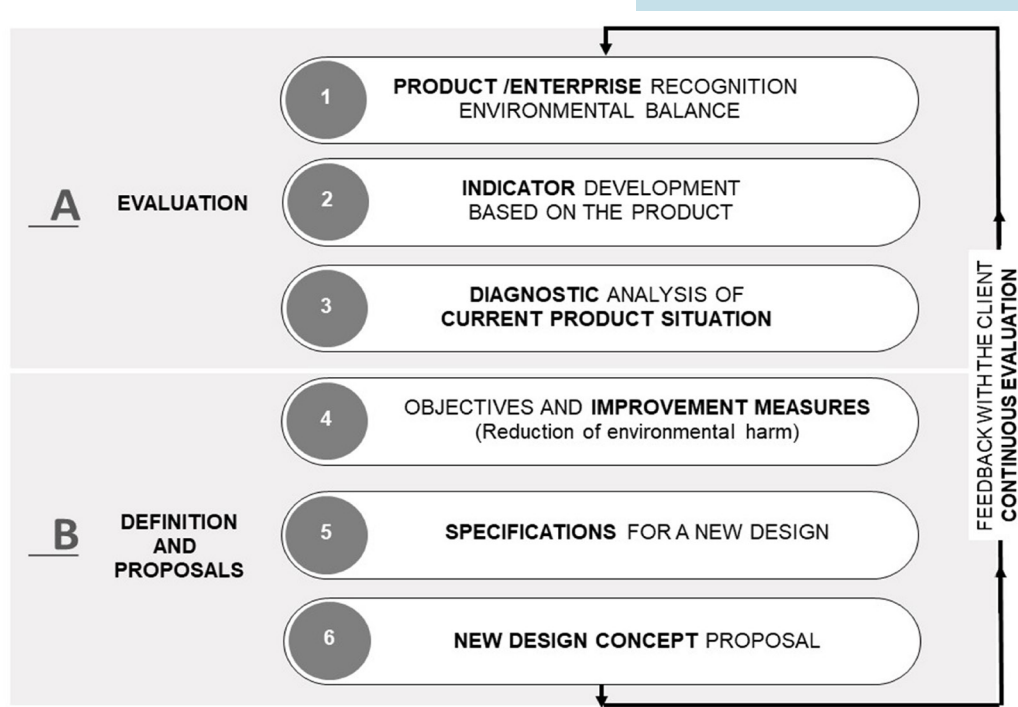


Figure 1. Phases and subphases for the proposed methodological framework. Source: Own elaboration, 2022.

client company, general descriptions of the product under evaluation, responsibilities, and project progress status. In the second part, the characterization of the product is established by a general breakdown of the unit into subunits and the weighing process in grams for each of them, along with the total weight of the system in question. This constitutes a significant collection of data that forms the basis of a simplified LCA process, which is ultimately the fundamental basis of the presented model.

a.2. **Indicator Development.** An evaluation of the product is carried out to quantify its environmental performance. For this purpose, the development of four (4) main indicators is estimated, derived from all the information gathered in the previous recognition and balance. These indicators are directly related to the EOL and are selected based on their relevance to the environmental optimization of the product. Each indicator aims to describe the level of adjustment of a specific system, subsystem, or part of a product (SSP) based on these indices. In general, lower adjustment values indicate closer proximity to the ideal state. Therefore, higher adjustment levels describe more critical issues that require more consideration from the designer to establish optimization strategies. Consequently, these indicators become a practical guide to obtaining an overall assessment of the product, resulting in a diagnostic scenario regarding its current state, from which potential improvements can be derived (de Aguiar et al., 2017). The following are the suggested indicators for the process:

- Indicator N°1, is the Environmental Impact of the Raw Material, and requires a general characterization of the product. The aim is to assess the origin of the material, its method of extraction, the possibilities of recyclability, and the hazardous nature of the material type that constitutes the product under evaluation.
- Indicator N°2, estimates an evaluation of the environmental impact regarding energy consumption associated with the use of the product being evaluated, its relationship with power, and the variable

of time in terms of usage for a specific period.

- Indicator N° 3, is defined as the functional evaluation of the product. This indicator establishes the direct applicability of the interface's performance and the user's assessment in terms of perceived efficient actions. Special emphasis is placed on functions related to the product's environmental management, such as EOL end-of-life considerations, disassembly, or durability, among others.

- Indicator N°4, establishes the evaluation of recoverability, considering the weighting of the number of present components, the number of materials, and the feasible joining systems identifiable in the overall product system.

a.3. **Diagnostic analysis of the current Product Situation.** This stage establishes the relationship between the collected indicators and the expected requirements in ideal terms. This analysis provides a diagnosis of the current state of the evaluated product, considering environmental requirements, and identifies areas for improvement. The principles and rules for this analysis are derived from a study proposed by the University of Delft by Brezet and Van Hemel (1997), The Netherlands, which suggests eight (8) Design strategies organized in the Life-Cycle Design Strategy (LiDS) Wheel. This application serves as a parameter for measuring relevant factors in ecological terms.

Phase B. Definition and Proposals

b.1. **Objectives and Improvement Measures of a Product.** The result of combining Eco-design strategies with the indicators identified in the preliminary evaluations is processed as a product diagnosis. This scenario can be represented schematically by applying a radial graph, which is essentially similar to the one developed by Brezet and Van hemel (LiDS Wheel). It synthesizes certain environmental issues into eight hierarchically ranked Eco-design strategies on a scale of one to ten. By recognizing each of the

obtained averages, it interprets different areas for improvement that should be addressed to advance in environmental optimization. Thus, the preliminary formulation of certain proposals begins, which could potentially align with the needs expressed by the client and be acknowledged as valid constraints associated with the project. In line with the opportunities identified during the product evaluation, this would prioritize the proposed ideas based on their immediate implementation feasibility and help to visualize future areas for continuous improvement processes (Iuga et al., 2017; Brones et al., 2017).

b.2. Specifications for a New Design. The weaknesses identified during the analysis of the product serve as a starting point for developing new design alternatives that overcome these deficiencies. However, these alternatives should align with specific Product Design Specifications (PDS), which ultimately express the feasibility of implementation and the contextual conditions required for effectiveness. In this regard, aspects related to the product's functionality and its implications for environmental optimization, as well as specifications related to technical factors of manufacturing/assembly that contribute to minimizing environmental externalities, and regulatory requirements mandated by institutions become the basis for defining and prioritizing certain criteria. These criteria, established within the PDS, facilitate the formulation of specific judgment elements that accompany the selection process of conceptual proposals and their subsequent development at the detailed design level.

The proposed PDS enable the formulation of certain criteria, which are assigned a value expressed as a percentage. Each criteria gains a hierarchy or weight, indicating its ideal importance in relation to the product system.

b.3. Proposal for a New Design Concept. The evaluation stage progresses by assessing each of the best-developed conceptual design proposals. Each proposal to be evaluated – in accordance with the predefined criteria – is assigned a final

weighting. To do this, the following steps are taken: a) each established criteria for the project is measured by assigning a score using relative scales based on the design team's needs or preferences (e.g., from 1 to 7 or from 1 to 10); the weighting is quantified by multiplying the percentage value by the score assigned to each criterion of the conceptual proposal ($\% \text{ Value} \times \text{Score} = \text{Weighting}$); finally, the total sum of all the weightings of the evaluated criteria determines a score for each conceptual design alternative. The option with the highest score is prioritized as a valid alternative to be further developed at the detailed Design level (Ulrich and Eppinger, 2009).

Results

A. Evaluation phase

The previously defined procedure was subject to testing and application in the work carried out by undergraduate courses in Industrial Design at the university level. Specifically, it was implemented in the Ecological Design workshop, corresponding to the seventh semester of the bachelor's degree program in Manufacturing and Industrial Design Engineering at the Universidad Técnica Federico Santa María, Viña del Mar campus, Chile. Therefore, this research is considered a preliminary instance that is feasible to be verified and corrected, thus allowing for potential scalability to other cases and contexts that aim to incorporate SD.

The results were presented as summarized and organized information according to the developed phase. Starting the process with the collection of necessary information for evaluation (phase a1), it involved the creation of a concise data matrix that allowed recording the balance of materials and components for further analysis. The study focused on a specific case where the main objective was to assess its environmental status and ultimately progress in its improvement. This was conducted on a low-complexity children wheeled product manufactured by Roda Corp. Spa., a Chilean brand. (Table 1)⁹

Table 1. Data Sheet a.1. Product Recognition and Balance. Source: Own elaboration, 2022.

		Product characterization matrix Sheet: A1		Review status: preview version		
Objective and Scope of product evaluation (Client brief): Progress in product environmental improvement based on initial diagnosis						
PRODUCT: RODA Classic learning bike			RESPONSIBLES:			
		Functional description: Wooden bike for preschool motor learning stage		In charge: Project manager		
				Department: Design and environment		
				Management m/a:		
				Professional in charge		
Product family: Yes (x) No ()			Design and development			
Typology Name: RODA learning bike			Professional in charge			
	Component	Number	Material	Weight(grams)	Origin	Source Mat.
Frame subsystem	Body	2	Plywood	1000	Chile	Virgin
Direction subsystem	Fork	1	Plywood	400	Chile	Virgin
	Handlebar	1	Plywood	200	Chile	Virgin
	Grips	2	Colored elastomer	200	China	Virgin
	Pivot axis	1	Common metal steel	400	China	Recycled
Wheels subsystem	Rim	2	Polymer	900	China	Virgin
	Tire	2	Elastomer/Rubber	580	China	Recycled
	Cogsets	2	Metal stainless steel	100	China	Virgin
Seat subsystem	Lift Support	1	Plywood	250	Chile	Virgin
	Support Structure	1	Plywood	200	Chile	Virgin
	Cushion/Saddle	1	Polymer/ Synthetic textile	100	China	Virgin
Junctions subsystem	Adjustment bolts	12	Metal stainless steel	150	China	Virgin
	Adhesive	1	Epoxy	20	Chile	Virgin
TOTAL				4500		

Based on the data obtained in sheet a1, the development of indicators was carried out, starting with those related to the environmental aspect and their impact resulting from the use of the previously identified raw materials in the product (sheet a2.1). For this purpose, the method proposed by Venegas et al. (2019) was adapted, which, through the breakdown of the total unit (product) into its different material subsystems, allowed for obtaining the percentage values relative to the weight (in grams) of each typology comprising the system. Therefore, the collected indicators, their weighting, and the criteria considered for this purpose can be observed in Table 2.

The second indicator measured the environmental impact in relation to energy consumption. To do this, the product was linked to its nominal power expressed in kilowatts (kW), the effective hours of use in an annual period, the estimated lifespan of the product, and finally the calculation to obtain the amount of energy consumed per hour (kWh) over a year, multiplied by the

years of use or lifespan (kWh/year * years of use).

In the case of the specific product being examined, which is a children's wheeled item activated mainly by human-powered mechanical traction or propulsion, the second indicator could not be calculated. Therefore, according to the criteria established for obtaining the indicator, the highest score is applied. This information was recorded in Table 3, which displays the result and the criteria applied for this purpose.

The indicator number 3, which assesses the functional performance of the product, was carried out by examining the various features that make up the product system and organizing them into subgroups. Each function to be evaluated was assigned a numerical scale to provide an objective reference for rating. In this regard, a hierarchical value or score (Sc) was created to estimate the degree of importance of each function within the system, using

Table 2. Sheet a.2.1. Environmental Impact and Raw Materials. Source: Own elaboration, 2022.

			Environmental impact matrix Sheet: A2.1				Review status: preview version			
Product Characterization			Material				Recyclability		Hazardousness	
Material	Weight(grams)	% Total Weight	Origin	Score	Source Mat.	Score	Recyclable	% recyclability	Hazard	Code DS 148
Plywood	2.050	45,6	National	5	Non-renewable	1	no	14,4	no	0
Colored elastomer	200	4,4	International	1	Non-renewable	1	no		no	
Common metal steel	400	8,9	International	1	Recycled	10	si		no	
Polymer	900	20,0	International	1	Non-renewable	1	no		no	
Elastomer/Rubber	580	12,9	International	1	Non-renewable	1	no		no	
Metal stainless steel	250	5,6	International	1	Non-renewable	1	si		no	
Polymer/ Synthetic text	100	2,2	International	1	Non-renewable	1	no		no	
Epoxic	20	0,4	International	1	Non-renewable	1	LiDs score	1,4	LiDs score	1
Total Weight	4.500	100,0	subtotal	1,5		2,1				
			LiDs score	1,8						

Material Criteria (Average of 2 atributes)		
Material Origin Criteria		
LOW	10 pt	If the product consumes local/regional mat.
MEDIUM	5 pts	If the product consumes national mat.
HIGH	1 pt	If the product consumes international mat.
Source Material Criteria		
LOW	10 pt	If the product contains recycled raw mat.
MEDIUM	5 pts	If the product contains renewable raw mat.
HIGH	1 pt	If the product contains non-renewable raw mat.
Recyclability Criteria		
HIGH	10 pt	80 to 100% recyclable mat.
MEDIUM	5 pts	40 to 79 %
LOW	1 pt	0 to 39 %
Hazardousness criteria		
LOW	10 pt	80 to 100% hazard mat.
MEDIUM	5 pts	40 to 79 %
HIGH	1 pt	0 to 39 %

a nominal scale from one (1) to five (5). A score of 1 represents the lowest level of importance, while a score of 5 indicates the highest level of interest for that function within the product system.

Bases on the above, the evaluation proceeded by specifically assessing each function within the system, using the predetermined rating scale. The voting (Vot.) was established on a scale ranging from very poorly resolved (1) to optimally fulfilled and resolved in the product, i.e., very well resolved (5).

Subsequently, a quantitative approach was taken to obtain evaluations in percentage points, which were recognized as functional indicators. For this purpose, the ideal sum (Σi) of each subsystem was calculated, derived from the sum of all squared Scores (Sc2); Similarly, the actual voting (A.V.) was shown in column 5, which combines the actual sum (Σa) of all products given the Score established for each function of the subsystem and its corresponding voting (Sc. x Vot.). Both sums are useful for calculating

the percentage (%) of compliance for each subsystem and function by applying a proportional operation. This information was recorded in column 6, representing the feasible level of conformity within the functional features of the entire subsystem.

In addition, the overall functional compliance of the product (in %) can also be noted by comparing the ideal total sum of the product (Σti) with the actual total sum (Σat).

Finally, functions that were evaluated and directly related to certain environmental criteria to be considered in the project were highlighted in yellow. For this purpose, it was estimated that associating 100% functional performance with a LiDS score scale of 1 to 10, where one point is equivalent to ten percentage points (1=10%), would be appropriate. All of the above, along with the collected indicators were recorder in Table 4.

The fourth indicator involved an analysis of the product's disassembly and its ease of accessing components for efficient recovery through recycling. The analysis assessed the EOL of the product, with a specific focus on Design for Disassembly (DfD). DfD refers to the current feasibility within the product system to prevent the destructive separation of its components, aiming to minimize waste at the end of its lifecycle and create opportunities for future recovery (Abuzied et al., 2020; Chiu and Okudan, 2010).

A detailed analysis was conducted, considering various indicators and the resulting LiDS score was recorded in Table 5, along with the corresponding weighting.

Completing the initial phase of Product Evaluation, a diagnostic analysis was carried out to assess the current environmental performance of the product. This involved establishing a correlation between the eight Eco-design strategies and the average of the indicators that align with these strategies.

As a result, the LiDS score was obtained, providing a basis for identifying potential areas of environmental improvement for the product in question. The data obtained from this analysis can be seen in Table 6.

Table 3. Sheet a.2.2. Environmental Impact and Energy Consumption. Fuente: Source: Own elaboration, 2022.

		Environmental Impact Matrix: Energy Consumption			
Sheet: A2.2					
Product	Power kW	Hr/year	Lifespan estimation (years)	Energy consumption during product use (kW x Hr/year x years of use)	
n/a					
Energy Usage Magnitude Criteria					
Evaluation	LiDs Score	Condition			
LOW	10 pts	If the product consumes less than 100 kWh			
MEDIUM	5 pts	If the product consumes less than 100-1000 kWh			
HIGH	1 pt	If the product consumes more than 1000 kWh			

Table 4. Sheet a.2.3. Product Functional Evaluation Matrix. Source:

	Product functional evaluation Matrix Sheet: A2.3				
FUNCTIONS	SCORE	VOTING	Ideal Score (Sc ²)	Actual Vot. (Sc x Vot)	
ROLL FOR MOVEMENT			Σi=73	Σa=43	subsys = 59%
Pull f/m	4	2	16	8	50
Balance	4	3	16	12	75
Stop	4	2	16	8	50
Roll	5	3	25	15	60
STEER			Σi=43	Σa=24	subsys = 56%
Maneuver f/m	3	1	9	3	33
Turn f/m	3	2	9	6	67
Steer	5	3	25	15	60
ASSEMBLE/DISSASSEMBLE			Σi=65	Σa=44	subsys = 68%
Hold f/a-d	2	1	4	2	50
Connect f/a	4	2	16	8	50
Secure Assembly	3	2	9	6	67
Adjust f/a	4	3	16	12	75
Disassemble f/transportation	4	3	16	12	75
Manipulate f/a-d	2	2	4	4	100
RESIST STRESS			Σi=57	Σa=39	subsys = 68%
Fix components to r/s	4	3	16	12	75
Distribute load to r/s	4	3	16	12	75
Resist bending	4	3	16	12	75
Resist torsion	3	1	9	3	33
MANAGE EOL			Σi=67	Σa=25	subsys= 37%
Disassemble f/disposal	3	2	9	6	67
Vary usage	5	1	25	5	20
Extend usability	5	2	25	10	40
Discard	2	1	4	2	50
Recycle	2	1	4	2	50
			Σti=305	Σta=175	Total product. =57%

** Lids Score

** Lids Score

** Lids Score

B. Definition and Proposals phase

Assuming the eight strategies of Ecodesign as a framework for addressing uncertainties that environmentally conscious Design should consider, the utilization of this references was determined to be a valuable input for generating new Design proposals (Liu and Zhao, 2020; Rungyuttapakorn and Wongwatcharapaiboon, 2020; Zhang and Li, 2019; Diago et al., 2019; Singh and Sarkar, 2019; Carey et al., 2019).

This scenario was schematically represented, using a radial graph, similar to the LiDS Wheel developed by Brezet y Van Hemel with the eight Ecodesign strategies hierarchically ranked on a scale from a one to ten. Additionally, a summary matrix was created, documenting the obtained LiDS score and the prioritized improvements proposals that have been chosen for implementation.

Based on the results obtained in matrix B1, the next step, known as the PDS, is established to guide the progression of

Table 5. Sheet a.2.4. Product Recoverability Evaluation. Source: Own elaboration, 2022.

		Recoverability Evaluation Matrix Sheet : A2.4					
	Component	Number	Material	Components number	Materials number	Joint System	
Frame subsystem	Body	2	Plywood	13	9	mixed	
Direction subsystem	Fork	1	Plywood				
	Handlebar	1	Plywood				
	Grips	2	Colored elastomer				
	Pivot axis	1	Common metal steel				
Wheels subsystem	Rim	2	Polymer				
	Tire	2	Elastomer/Rubber				
	Cogsets	2	Metal stainless steel				
Seat subsystem	Lift Support	1	Plywood				
	Support structure	1	Plywood				
	Cushion/Saddle	1	Polymer/ Synthetic textile				
Junctions subsystem	Adjustment Bolts	12	Metal stainless steel				
	Adhesive	1	Epoxic				
Subtotal				1	5		
Average				3,7			
LiDs Score				3,7			

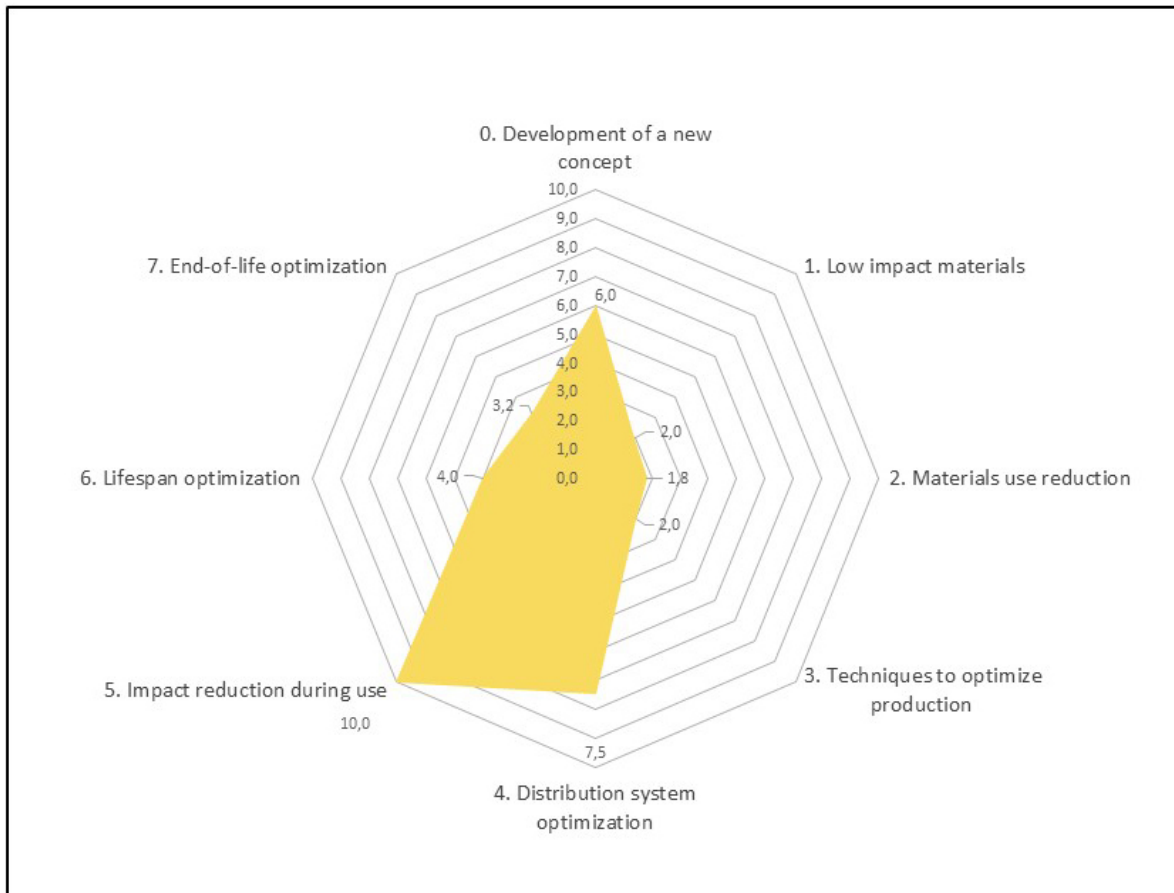
Recoverability Criteria (Average of 3 attributes)			
Components number			
LOW	10 pts	If the product has up to 3 pieces	
MEDIUM	5 pts	If the product has up to 6 to 10 pieces	
HIGH	1 pt	If the product has more than 10 pieces	
Materials number			
LOW	10 pts	If the product has up to 3 materials	
MEDIUM	5 pts	If the product has up to 6 to 10 materials	
HIGH	1 pt	If the product has more than 10 materials	
Joint System			
LOW	10 pts	If the product presents transitory joint system	
MEDIUM	5 pts	If the product presents mixed joint system	
HIGH	1 pt	If the product presents permanent joint system	

Table 6. Sheet a.3.1. Scenario Analysis for Ecodesign. Source: Own elaboration, 2022.

ECODESIGN STRATEGIES	Scenario Analysis for Ecodesign Matrix Sheet : A3.1						
	Material	Recyclability	Hazardousness	Use Energy	Usability	Recoverability	Average
0. Development of a new concept				10,0	2,0		6,0
1. Low impact materials	1,8	1,4	1,0			3,7	2,0
2. Materials use reduction	1,8						1,8
3. Techniques to optimize production		1,4	1,0			3,7	2,0
4. Distribution system optimization					7,5		7,5
5. Impact reduction during use				10,0			10,0
6. Lifespan optimization					4,0		4,0
7. End-of-life optimization		1,4	1,0		6,7	3,7	3,2

Table 7. Sheet b.1. Diagnosis and Ecodesign Strategies. Source: Own elaboration, 2022.

ECODESIGN STRATEGIES	Diagnosis and Ecodesign Strategies Sheet : B1						
	Material	Recyclability	Hazardousness	Use Energy	Usability	Recoverability	Average



Items	Lids Score	Proposal	Conclusions per Item
0. Development of a new concept	6,0		
1. Low impact materials	2,0	Prioritize materials made from recycled or renewable sources	Enhace the application of recycled wood, steel, and polymers
2. Materials use reduction	1,8	Minimize number of materials	Limit the variety of materials to a maximum in structural, mechanical, and operational systems
3. Techniques to optimize production	2,0	Simplify manufacturing processes and their relationship with designed parts	Fewer parts, fewer operations
4. Distribution system optimization	7,5		
5. Impact reduction during use	10,0		
6. Lifespan optimization	4,0	Extension of durability in use	Expansion of functions based on user age. Older age, additional functions
7. End-of-life optimization	3,2	Simplify collection for recycling	Facilitate disassembly for EOL

Table 8. Sheet b.2. Design Proposal Selection. Source: Own elaboration, 2022.



Design Proposal Selection Matrix

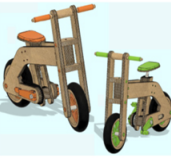
Sheet: B2.











		Concept (A)		Concept (B)		Concept (C)		Concept (D)	
Selection Criteria	Value (%)	Grade	Weighting	Grade	Weighting	Grade	Weighting	Grade	Weighting
Restriction of material variety	30	5	1.5	5.5	1.65	5.5	1.65	5	1.5
Recyclability and renewability of materials	25	4	1	5	1.25	5	1.25	5	1.25
Optimization of parts and its production	15	3	0.45	5	0.75	5.8	0.87	4.5	0.675
Simplified disassembly for recycling	15	6	0.9	5.5	0.83	5.5	0.83	4.8	0.72
Extended durability through use	15	5	0.75	4	0.6	5	0.75	4	0.6
	Total points		4.6		5.1		5.4		4.7
	Selection		4		2		1		3
	¿Choose?		No		No		Yes		No

Infant Bike. Proposal and details Design.

Design: P. Castro/ E. Barahona

Design Work Team: M.Celedón/ V. Dosow/ M.Droguett/ K. Fernández- UTFSM

Professor in charge: Marcelo E. Venegas Marcel



KIDS

BICICLETA DE APRENDIZAJE

Con la bicicleta de balance de "Kids" los niños podrán jugar mientras aprenden a desarrollar equilibrio y a fomentar su coordinación motriz.

ASIENTO
Altura ajustable

PEDALES
Plegables

EN 3 SIMPLES PASOS

BICICLETA

EJE EXTENSIBLE
Sistema por hilo permite extender el eje trasero para ruedas triciclo

ACERO
100% reciclado

LACADO
Ecológico y atóxico

MADERA
Material sustentable

MADERA LAMINADA
18 mm Pino radiata y Maño
El conjunto de placas de madera de Pino y Maño, logran un material resistente y estable, que permite crear un material económico y ultra resistente

BALANCE 3 EN 1

Ideal para niños de 2 a 7 años

MODOS DE USO RECOMENDADO SEGÚN EDADES:

- 2** TRICICLO
Triciclo sin pedales para el desarrollo del equilibrio
- 5** BICICLETA DE EQUILIBRIO
Diseñada para aprender a maniobrar sobre dos ruedas
- 7** BICICLETA CON PEDALES
Ya están listos para su bicicleta con pedales!

SISTEMA DE UNIÓN
Pernos bajo relieve, la bicicleta viene PREARMADA ¡sólo necesitas llave allen!

SISTEMA TRACCIÓN
Conectados por correa de distribución y engranaje

RUEDAS
Marcha silenciosa y suave, libre de pinchazos gracias a la espuma de densidad media en vez de cámara inflable. Esto evita pinchazos y posterior reparación o cambio de cámaras.

TRICICLO

SISTEMA DE RODADO
Rodamientos transfieren el movimiento y transmiten la fuerza para permitir el rodado

Figure 2. Proposal and Detailed Design for the Product. Source: Adapted by the author from de Castro and Barahona, 2022.

the alternative generation and evaluation process. It is understood that the strategies with lower scores serve as the starting point for defining the criteria to be used in the selection process of those alternatives. The derived criteria for selection are as follows: a) restriction of material variety; b) recyclability and renewability of materials; c) optimization of parts and production; d) simplified disassembly for recycling; e) extended durability through use.

The process of alternative selection and the corresponding weighting based on these criteria can be observed in Table 8.

For the specific product under consideration, a concept that aligns with the established criteria and weights was selected. This concept was further developed into design solutions that address usability and detailed aspects, as depicted in Figure 2.

The developed concept is ready to be prototyped and can continue to be evaluated and optimized with a perspective of continuous improvement. This includes integrating new requirements from the client for environmental optimization and considering any new regulations established by environmental institutions.

Conclusion

-The proposed method allowed the identification and characterization of a product, considering the future reduction of environmental externalities generated by each of its components, the composition of its materials and its production characteristics. This was achieved through the registration of an abbreviated environmental assessment, based on the selection of the most relevant and priority aspects for this purpose. Thus, it presents a schematic collection of information, organized with key data that constitute and define the physical material system under analysis.

In this way, this instrument would serve as a valid tool to address Product Design projects, whether viewed from the required pedagogical needs, the learning criteria in the teaching of different project workshops, or

specialized subjects. Additionally, it can also be applied to projects that require an efficient resolution under productive parameters, but with an environmental perspective. Ultimately, it acts as a guide that facilitates the evaluation of potential scenarios to be considered in decision-making processes for improving manufactured products, but with a sustainable perspective.

- The procedure presented here emphasized the importance of considering objective criteria to proceed accurately with the analysis and subsequent formulation of environmental indicators associated with products. This constitutes the updated framework to be considered as the starting point for each specific case to be addressed, thereby ensuring the necessary prior planning of an agile and efficient structure capable of responding to the various changes in regulations defined by environmental institutions.

-The initial diagnosis directly influences the prioritization of environmental improvement strategies applicable to the development of new Product Design proposals. These measures should guarantee not only the functional aspects derived from practical and utilitarian user needs but also the specific production requirements defined by the client. This allows for a targeted and regulated selection of the proposed improvements in project optimization. Thus, the relevance of having an objective and weighted evaluation of the various conceptual alternatives that arise during the design process undertaken by the development team is confirmed.

In this regard, the Selection matrix (b2) appears to be an efficient evaluation tool in response to the demanding requirements suggested by the different criteria considered in the search for the optimal Design solution.

- The Design solution that was implemented aligned specifically with the diagnostic overview obtained through the application of the proposed method. Although it was challenging to determine the indicator associated with recyclability due to the existing and updated recycling infrastructure

in the area, it was addressed nominally considering the nature of the raw material. This confirmed that the proposed instrument is flexible in the need to test the definition of indicators, even in the presence of limited general information. This allowed the verification of the flexibility of the methodological instruments and the scalability in their application, as indicated by Favi et al., (2019), this flexibility should be reflected in both educational projects within the university setting and, in the context, related to the needs of the company.

- Likewise, it was highlighted that the Design solutions developed through the application of the instrument place special emphasis on EOL as a relevant strategy applied to the product in question. This focuses primarily on the recyclability of waste, disassembly, and the reduction of the product's volume, aiming to facilitate the collection and final management of the materials that make up the system. Therefore, it is concluded that this approach, although not the only one addressed in the project, would contribute to the future collective integration of the principles that underpin good environmental practices (Rossi et al., 2016).
- It is important to note that, for the purpose of this work, certain variables were simplified in order to align with Ecodesign strategies. This includes the environmental regulations applicable to the EOL stage of certain products (such as EPR law, prioritized products). However, despite these simplifications, it is possible to continue refining the instrument in terms of more precise quantification, even while using the LiDS wheel as a basis.
- The research conducted is potentially adaptable to the evaluation and analysis of typologies of product families. This opens up an important opportunity to further refine the obtaining of weighted indicators. It allows for a potential cross-referencing of information derived from the comparative evaluation of products

developed within a company or within a specific productive sector. This facilitates the identification and subsequent resolution of various environmental bottlenecks associated within materials and/or processes (Valero et al., 2018; Brundage et al., 2018).

- The presented work represents an initial methodological trial applicable to improving products from an environmental perspective. It establishes simplified procedures, centered around the fundamental concepts of Ecodesign, that can be readily incorporated into the most common phases of the Design process. It is expected that in the near future, these tools can be gradually integrated into academic exercises within various design workshops that choose to address the challenges of SD in their projects. Additionally, these tools can be used to prototype solutions for professional practice within companies, tailored to the specific needs of clients. By doing so, the concept of environmental continuous improvement can be embraced, advancing the notion of quality associated with sustainability.

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Review | Revisión

Women in Industrial Design: A review | Mujeres en el Diseño Industrial. Una revisión

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Abstract:

In most countries, women are underrepresented in the industrial design industry. Some people argue that this is because women do not work hard enough to be good designers, so they do not get hired for jobs. Others argue that women are discriminated against in the industrial design industry, leading to their underrepresentation. In this paper, I review the research on women in industrial design to look for answers regarding the gender patterns seen in the industry. I employ theory from feminist Science and Technology Studies to explain how industrial design may be cast as a “masculine” field due to its association with technology, and areas of design where women have traditionally worked are considered “craft” rather than design. I describe how and why professional cultures and educational spaces in industrial design can be unwelcoming to women. I discuss how queer understandings can better inform our work in gender and design. I conclude with recommendations for future research and initiatives aimed at achieving better gender equality in the industrial design industry.

Keywords: Industrial Design; Female designers; Gender; Design Practise; Design Education

Introduction

Though the fact that women are underrepresented in the industrial design profession is not new, the issue has recently been gaining more attention. In 2020, a female industrial designer based in San Francisco, California, Ti Chang, published an Instagram post with some statistics from a UK report by the Design Council. The report stated that women make up 63% of students studying creative arts and design at university, yet design professions remain 78% male, and the specific field of

product and industrial design is 95% male. Women working as product, clothing, and related designers earned 18.3% less than their male counterparts, and only 17% of design managers were female (Design Council, 2018). Chang wrote in her post that the statistics shared by The Design Council were “vindication of my suspicion that female industrial designers worldwide are simply not being hired. And when they are, they are earning less than men” (Ti Chang [@designerti], 2020). Chang’s post is shown in Figure 1.



Figure 1. Instagram post by @designnerti sharing statistics about women in design from the Design Council's 2018 report. The image reads "These design statistics will shock you #DesignEquality #BiasInDesign." The accompanying comment by the author reads "You know that feeling when you know something is true but not sure if it is a fact? These 2018 statistics from The Design Council @designncouncil is vindication of my suspicion that female industrial designers worldwide are simply not being hired. And when they are, they are earning less than men. Upon graduating in 2002 from @georgiatech Industrial Design, I noticed that I was [among] only a handful of women who got jobs in industrial design. I couldn't understand why we see so few women in the profession despite having more than 50% of industrial design majors to be women."

Chang's post was soon re-posted by Yanko Design, a design site with an international following (Yanko Design [@yankodesign], 2020). What drew even more attention to Yanko Design's sharing of the post were the comments that their post received. Many members of the design community left comments arguing that the field of design is purely meritocratic, and if women were getting disproportionately fewer design jobs, then it was due to female designers' lack of talent or effort. Some examples of the comments follow:

@jackdean6: "Yeah, when you go into a field where getting hired is based off of skill and what you can produce not what gender you are, it is possible to see stuff like this."

@daniel_pgtr: "I studied architecture. There were like 10 women in my year at the

beginning and only like 4 at the end of the career. They just couldn't take the pressure, it was very common to see a girl cry."

@nxsaif: "Best people get hired regardless of what sex they belong to." "How many of the 63% [of female design students] even have their portfolios on Behance?"

@deependuajish: "It doesn't account for the extra hours males put in, likelihood of moving location, having a disagreeable temperament; all of which gets clouded by a disingenuous and ignorant statistic."

@troofbetold_: "Design is purely skill/talent based. So as a recruiter, you don't look at the gender of the applicant, you just look at how good their portfolio is...being promoted in the design industry is all about experience and skill."

@carla_trdz: “I’m not outraged, perhaps the reason more males are in the workplace is because they’re capable at what they do. Simple.”

@stevo.mansell: “Just get good.”

@danielgalanofficial: “I could take care of 10 children and it would barely start to resemble the effort I put into having a successful design career. Instead of reading too much into these stats, women should go out there show us with facts that they are as competent.”

While Chang’s original post argued that discrimination against women designers was to blame for the lower representation and lower pay of women in the design industry, the above comments point to a different narrative. The commenters argued that women were less “good,” less “competent,” less “capable,” have less “skill,” “couldn’t take the pressure,” didn’t put in as many hours, were unwilling to relocate for a job, and have a “disagreeable temperament.” In other words, they argued that most women, even if they are interested in design and enroll in design school, are simply not cut out to be designers.

The online comments shared above do not represent the findings of an objective scientific investigation but are included here to provide background context of a debate that is going on among designers. People know that there are fewer women in the industrial design profession, but there is not a consensus as to why. If anything, the comments demonstrate that there are designers out in the world who hold very strong opinions about the explanation. In this paper, I will review the literature on women in industrial design in order to bring insights from research into the discussion. Women indeed face many barriers to advancement and acceptance in design, but our reality is much more complicated than what the Instagram discussion let on. I will conclude with recommendations for ongoing research and initiatives addressing gender and industrial design.

I am white American and an English speaker, and my review of the literature for this paper was limited to English-language articles appearing in English-language databases. Thus, this paper does not comprehensively represent world perspectives, and has a Eurocentric and Anglocentric bias in terms of which literature is represented and in terms of my own cultural background and perspective as an author.

Patterns of women’s representation in the industrial design profession

While Design Council’s (2018) statistics revealed a wide gap between the percentage of female design students and professionals, patterns of representation change over time and differ by country. In 1990, authors Bruce & Lewis noted that less than 1% of industrial designers in the UK were women, which is lower than the 5% shared in the Design Council’s report, though not by much (Bruce & Lewis, 1990). Bruce said women were “invisible” in the industrial design profession. The profession was seen as masculine, and women’s underrepresentation was justified by sentiments like the fact that industrial designers must work alongside male engineers “who would not take orders from or listen to a woman” (Bruce, 1985, p. 151). Bruce proposed that an industry-wide strategy would be needed in order to challenge the ideology of the sexual division of labor in industrial design (Bruce, 1985).

In 1974, the industrial design profession in the United States was only 13% female, while the proportion of female students studying industrial design at a University was only 19% (Jenkins, 1982). The proportion of women in industrial design lagged behind other design professions such as fashion design, graphic design, and interior design, but exceeded the representation of women in architecture, which was only 5% female (Jenkins, 1982). More recently, the Industrial Design Society of America (IDSA) reported that now 50% of student members are female, 42% are male, and 8% are

nonbinary. Among professional members, only 27% are women, 69% are men, and 0.5% are nonbinary (3.5% unreported) (IDSA HQ, 2021). Thus, over time, there has been an increase of women in pursuing industrial design in university and industry in the United States, even though the industry remains gender imbalanced.

Representation of women in industrial design is not the same in all countries. Turkey has historically and presently seen a much more equal gender representation in industrial design. In Turkey, 47% of ID graduates are women, and 47% of members of the ETMK (Industrial Designers Society of Turkey) are also women (Kaygan, 2014). While Turkish female industrial designers do face various challenges, Turkey appears to lead other countries in terms of proportional representation in both university and industry, though not necessarily by rank, as women are still underrepresented in design leadership.

Ultimately, we need more data on women in industrial design. 2021 appears to be the first time that the IDSA reported statistics on gender and race, and the statistics were limited and did not discuss rank or pay. Furthermore, women may be overrepresented in professional organizations, which only represent a small slice of the wider design industry. More rigorous data collection and analysis is needed to understand the true picture of how women are faring the industrial design profession. However, statistics cannot tell the whole story. Many researchers have used qualitative methods to study the experience of women in industrial design, which I will now discuss.

A view from Feminist Technology Studies

As I begin my discussion of qualitative research on women in design, I want to introduce a helpful interpretative lens provided by the field of Science and Technology Studies (STS). Feminist scholarship in STS views the concept of “technology” as co-constructed or

co-created with gender. Rather than an expression of biological sex, gender is a pattern of social relations in which differences between bodies are brought into social processes (Connell, 2021). Boundaries around professional domains are not accidental or arbitrary but are often drawn alongside gender patterns. The lack of women in “technical” professions such as industrial design is no accident – this dynamic has been historically and intentionally constructed. Domains of skill generally pursued by men are labelled “technical” while those mastered by women are considered “craft” (Johnson, 2010). “Technical skill” and “technology” are concepts that are considered to be masculine, and on the flip side, women are portrayed as unskilled with technology or less interested in it (Johnson, 2010). Technology has often functioned to further the oppression of women, guided by the hands of male decision-makers who hold the power over technological systems (Trescott, 1979). Gender divisions of labor around technology persist in part because people tend to equate masculinity and technical skill (Faulkner, 2001). As industrial designers are in the business of creating new technology, the concept of the co-construction of gender and technology can help explain the masculinization and male dominance in the industrial design profession.

Industrial designers work closely with engineers, and engineering is another discipline cast as “technical” and “masculine.” Kaygan (2014) argued that relations between engineers and industrial designers are constructed around symbolic dualisms, including ‘real’/‘arty’, objective/subjective, technological/aesthetics-based, and masculine/feminine. When placed next to industrial design, engineering is seen as ‘real,’ objective, technological, and masculine. Next to engineering, industrial design is seen as ‘arty,’ subjective, aesthetics-based, and feminine. When working in organizations that valued the technical sides of these dualisms, industrial designers found themselves in a position of disadvantage next to engineers. For women

in industrial design, the disadvantaged status of being a designer rather than an engineer intertwined with being a woman and deepened their “gender inauthenticity” for technological work (Kaygan, 2014, p. 85). Industrial design’s proximity to technology and engineering is likely something that masculinizes the discipline, meaning industrial design is seen as more suitable for men, industrial designers are normalized as male, and female designers are seen as less talented simply because of their gender. In studying the industrial design field, Reimer (2016) found that understandings of creativity, craft, knowledge, and innovation may be presented as gender-neutral but often describe a subject who is presumed to be male. Design discourse normalizes designers as male. For example, a design team may be referred to as “the guys” (Reimer, 2016, p. 1036). Male stereotyped perceptions of the “creative genius” also persist (McMahon & Kiernan, 2017, p. 5). Our ideas about professional suitability and skill are shaped by our ideas about gender, and our ideas about gender also shape our images of professional ideals. This is something we cannot ignore.

Gender and design areas and skills

One way gender functions as a pattern of social relations is that depending on a person’s perceived gender, they are viewed as more suitable to work in certain areas of design. Women who enter the industrial profession are seen as more “naturally” talented in styling, color, appreciation of the end user, jewelry, textiles, graphic illustration, and pottery (Bruce, 1985; Bruce & Lewis, 1990; Buckley, 1986). Design historians have also placed the highest value on mass-produced objects and left many women out of design history by ignoring the areas that have been more accessible to women, including craft modes of production and fashion design (Buckley, 1986). Thus, women are not always given a real opportunity to enter all parts of the design profession as they are often pigeonholed into certain areas (Bruce & Lewis, 1990). Furthermore,

these areas that are seen as more suitable for women are not the “technical” skills which are highly valued in industrial design and are instead seen as “craft” or “soft skills,” which are categories that are both associated with women and less valued. Traditionally the favored “technical” skills in industrial design included hand sketching and physical model-making in a machine shop. More recently, skills in computer-aided design (CAD) software and computer rendering software are also important to the profession, and one third of design roles are digital (Design Council, 2018). These new “technical” skills are likely being seen as something less suitable for women or something that women have less talent in, regardless of whether or not that is the reality.

Women with degrees in industrial design appear to be presently more highly concentrated in roles like design research, UX research, toy design, baby product design, soft goods, textiles and fashion, or color/material/finish (CMF) design. However, hard data on this is difficult to find, and more research is needed. We can explain this phenomenon through a “push-pull” model. Women may be pulled to the “softer” fields if they find the subject matter appealing. However, women also may find themselves pushed into the “softer” fields because teachers, co-workers, or bosses encourage them in that direction based on gender stereotypes. Women also may be pushed out of “harder” sub-fields due to negative experiences that made them want to leave. In contrast, male designers may avoid “softer” fields because they associate them with femininity, and they don’t want to be seen as feminine, particularly when they are trying to assert their position and expertise next to engineers, who already view design as a “softer” field to begin with. For example, a male designer who was working in the more female-associated area of design research reported choosing the job title “design strategist” instead of “design researcher” because he felt the title “design researcher” didn’t sound as masculine (Ronen, 2018, p. 525).

Gendered patterns of unpaid labor after work hours may also influence gender patterns in design subfields. A 2019 Australian study found that technology-related skills, which are highly valued in the architectural profession, were mostly gained in a self-directed manner outside of work hours. Invisible labor practices that disadvantage women were thought to be the reason that more men than women were engaging with computationally intensive design software, as they had more spare time to do so (Gardner, 2019). It is likely that female industrial designers are not spending as much time outside of work hours attempting to build their computer-related design skills, at least in part because women have to take on more unpaid labor in the home, such as cooking, cleaning, and childcare. Another factor may be that women are more frequently taking a more balanced approach to using their time and not spending all their free time on the computer, such as has been observed with male and female computing students. However, a critical lens would question why “technical” skills are seen as bringing more added value to a firm than other “non-technical” or “soft” skills that are also honed outside of work hours, such as management and communication skills.

Cultures of overwork, competition, masculinity, and assimilation

Creative design fields foster cultures of overwork, competition, and masculinity (Reimer, 2016), which may contribute to women feeling less welcome in industrial design jobs. In a study involving UK designers, working at a consultancy in London was valorized, while working outside London or for an in-house team (a design team within a larger corporation) was disparaged (Reimer, 2016). A branding agency director suggested that employees who were not “good enough” for his firm would go to work as in-house corporate designers to seek an easier lifestyle, and he later suggested that women with children would be especially likely to go this route (Reimer, 2016, p.

1041). A male design director reported that smaller firms “find it difficult to take on the liability of someone who may go off and have a baby” (Reimer, 2016, p. 1038). In spite of the fact that this kind of discrimination is illegal in the United States, a young American female designer reported being asked during her interview if she planned to get pregnant (Advanced Design, 2021). Another young designer reported having to turn down an industrial design internship offer because all interns were required to live in the company-provided apartment, which could not accommodate her newborn child (Advanced Design, 2021). Thus, women who have children or are perceived as potentially having children in the future are facing more difficulty getting hired at some design corporations. More research is needed to understand how widespread this phenomenon is and how much of an impact it is having.

Design firms reproduce a homogeneous male culture because hiring is often based on personality and “fit” (Reimer, 2016, p. 1037). Female designers in Ireland reported issues with workplace culture including inappropriate behavior directed toward them, having to work harder to be taken seriously on projects (especially “technical” projects), and being discouraged about their own prospects of advancement if they did not see women in leadership (McMahon & Kiernan, 2017). A comprehensive study of gender and racial issues in architecture revealed that both gender and racial discrimination were rampant problems in the profession. Underrepresented architects were often pigeon-holed into certain areas of work. Significant pay gaps existed between men and women architects and widened in higher ranks of the profession. A leap-frogging phenomena was present, where men with less experience were able to climb the corporate ladder more quickly than women with more experience. Women of color reported the lowest levels of satisfaction with their future career prospects. Many female architects reported having traded a family life for a career, while male architects did not experience this tradeoff (Anthony, 2001). Though less

research has been done on workplace discrimination, pay discrimination, and jury bias in industrial design, it is likely that the similar patterns to those in architecture would be found.

A behaviour of avoiding discussing gender or gender differences has been observed among industrial design professionals (Ronen, 2018). However, these discussions are increasingly being had in academic and professional settings. In a presentation titled “How to Lose a Female Designer in 10 Days,” female industrial designers Mallory Evans and McKayla Barber illustrated a story in which a female designer joins a design studio and shows up on the first day wearing a patterned skirt (Figure 2). By the end of the story, the designer has experienced lots of disparaging comments in the workplace, and has also assimilated her clothing in order to blend in. In the end, she is wearing the typical architect/designer uniform of a plain black T-shirt and pants in an effort to assimilate with her male colleagues (Evans & Barber, 2019). Through this storytelling, the two young female designers expressed a reality about design culture, that female designers face pressure to change the way they present themselves in order to fit into male-dominated design workplaces.

Gender and design education

Women were historically not welcomed into industrial design education programs. Originally, the industrial education movement, involving courses like wood and metal work and mechanical drawing,

was designed to prepare men for careers in paid employment, and the equivalent offering for women was home economics courses (Rury, 1984). Early arguments for the inclusion of women in industrial education courses like shop classes were rooted in the fact that housewives needed to know how to repair and maintain mechanical and electrical devices in order to perform housework, because, in the United States at the time, it was assumed that most women would eventually become housewives (Wells, 1946). While it is easy to believe that women are no longer steered away from certain professions because of their gender, recent research shows this is not the case. Female industrial design students in Ireland reported being encouraged to pursue more “academic” subjects or traditionally feminized disciplines (McMahon & Kiernan, 2017, p. 3), suggesting that the gendered nature of the industrial design discipline may be preventing women from being supported in their pursuit of it.

The gendered nature of the skills taught, masculine-oriented project topics, and masculine-oriented artistic styles are all factors that female students have reported to be discouraging during their studies industrial design. A Norwegian university had an imbalance where nearly all the students choosing service design were women, and nearly all the students choosing industrial/product design were men. A female graduate explained why she chose service design as her concentration, and why she believed more women were choosing service design and more men

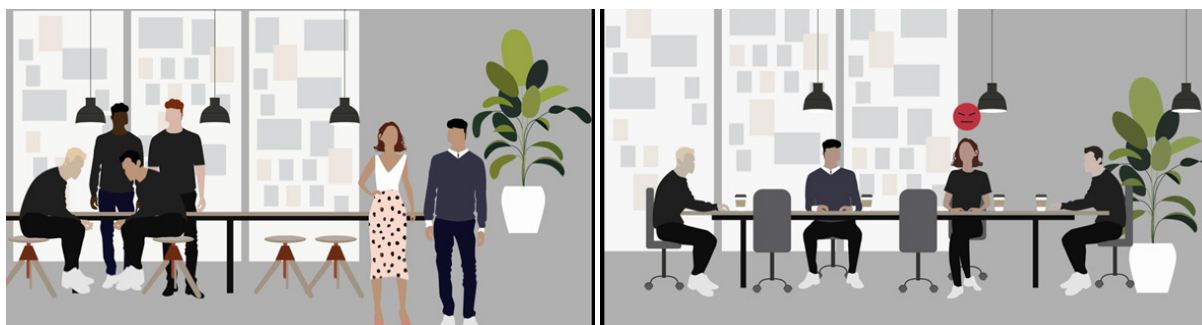


Figure 2. Left image is a drawing of a professional industrial design studio. Five male employees are dressed in all black clothing, and a female employee is dressed in a white tank top and a pink polka-dotted skirt. The right image shows the same design studio, and the male employees are still dressed in all black clothing, but now the female employee is also dressed in all black. A red angry face emoji is above her head. From Evans & Barber (2019).

choosing product. She said, “when I think of product design, the first I think of is very masculine drawings which are not relatable to me.” She cited drawings of cars and drawings in the style of Koos Eissen as examples of “typical” industrial design drawings which she felt distanced from, because of their “un-personal, masculine style” (Bjørnstad, 2018, p. 5). She thought a greater variety of expression would encourage more girls to become industrial designers. Similarly, a United States-based study of industrial design sketching abilities found that while five out of six male students had prior experience with the common industrial design sketching style, none of the female students had prior experience in this style and only reported experience with a more “fine art” sketching style. The female students also preferred the “fine art” sketching style (Barnhart & Walters, 2018, p. 3). A female designer reported being told that she sketched “like a girl,” as an implication that her sketches were done poorly or weakly, similar to being told “you throw like a girl” (Ronen, 2018, p. 524). Barnhart & Walters hypothesized that the industrial design style of sketching and idolization of the “hot sketch” was a contributor to gender disparity in the industry (Barnhart & Walters, 2018, p. 1). Besides sketching, a female design student reported that CAD programs like Solidworks and Catia felt “very technical and not relatable” (Bjørnstad, 2018, p. 5). Female students in Australia also perceived themselves as not starting off at the same level as male students at the beginning of the CAD software courses due to having had fewer life experiences with those skills (Lockhart & Miller, 2016). The study also found that female industrial design students initially perceived the machine shop to be a daunting, “gendered” environment. Female students also felt that they started off behind due to having less prior experience in this area than the male students (Lockhart & Miller, 2016). Another study of university students in product and industrial design in the UK found design to be a “gendered discourse,” where technical competency was seen as gendered, and tools like hammers, locations like the

workshop, and computing skills were experienced by women as gendered (Clegg et al., 1999, p. 44).

The socially constructed connection between shop tools, computing tools, technology, and masculinity is clear. Although there are many female students who enter university with expertise in CAD and workshop, and there are plenty of female students who excel with and embrace the typical industrial design sketching style, we should be mindful of the fact that for many women, throwing themselves into these domains may feel like a violation of gender norms. Furthermore, industrial design instructors should be mindful of the fact that their students are raised in a society in which people are socialized very differently based on their gender, and that this affects the types of skills that people are encouraged to obtain prior to entering university. It is clear that CAD skills are currently essential for most industrial design roles. However, I question whether high-fidelity sketch rendering continues to be of wide importance in the industry now that computer-aided rendering with software such as Keyshot is so popular. The emphasis placed on a particular sketching style may now be an irrelevant and unnecessary gatekeeping tool. Similarly, machine shop skills may not be as important as they once were now that 3D printing is so widely used in the prototyping process. Future research should seek to understand what skills are most used in the design industry day-to-day to better align education with industry and ensure that gendered domains aren’t serving an unnecessary gatekeeping purpose.

Another potential problem area regarding the gendering of design education is project topics. Female industrial design students in Australia reported feeling that course projects were generally more in-line with “masculine interests” such as designing power tools and cars, and this limited their interest and engagement in the course (Lockhart, Cathy & Miller, Evonne, 2015, p. 4). A study in engineering design found a similar phenomenon, that the project domain of

group assignments could be viewed as more oriented to one gender than another, which may contribute to female students feeling undervalued by male peers and lower self-efficacy reported by females (Okudan & Mohammed, 2006). Design educators should be more careful to select project topics that the students agree are gender-neutral or that appeal equally to all students.

Finally, critiques and juries are long-standing pedagogical methods in industrial design, yet the possibility of gender or race-based discrimination during design juries and critiques is very under-studied. One study of design juries found patterns of prejudicial behavior among and between jurors and students of different genders and races, and suggested that this phenomenon likely discourages talented female and/or racially minoritized students from continuing in school or in the profession (Frederickson, 1993). To further study this phenomenon, it would also be useful to look at how jurors and reviewers react to the types of projects presented by students. Could it be that women are penalized for presenting a project from a female-associated domain, such as a baby product, since they are confirming gender stereotypes, while the same project might be praised if presented by a man? Future studies could investigate questions like this.

Gender essentialism and queer understandings

Thus far I have primarily focused on the experiences of women in industrial design, but gender is not a fixed binary. Although femininity and masculinity are helpful concepts in the sense that they can be used to explain socially constructed categorizations that impact gender distinctions, our reality is more complex. Masculine and feminine are not two ends of a spectrum, instead, there are multiple different masculinities and femininities (Connell, 2021). Furthermore, there are many people who identify as non-binary or do not identify with a gender at all. Some

researchers have aimed to incorporate queer understandings of sex and gender into design research and practice (Denz & Eggink, 2019; Prochner, 2014). Prochner (2014) argued that while projects that critique typical binary gender encodings into products are useful, for example, designing a power tool with a more “feminine” look, these projects would be more valuable if they went on to represent gender as more of a broad spectrum instead of a binary (Prochner, 2014). Some projects that have sought to better represent women’s voices in design have taken a position that essentialized gender or put women in a box (Prochner, 2014). For example, the woman-focused design initiative *Femme Den* believes female users can be categorized and that they required an emotional connection with products (Prochner, 2014). Their website states, “a woman’s purchase decisions reflect her good judgement—and it’s not easy to gain her trust because it’s personal and emotional” (*Femme Den*, 2023). Ronen (2018) found that postfeminist ideology in the US industrial design industry was contributing to the celebration of essentialized or fixed gender differences while simultaneously overlooking women’s devaluation (Ronen, 2018). Designers need to be careful that our arguments for including women in industrial design do not put women into a box, such as by saying things like “women are more emotional and better able to empathize with users.” We also need to be careful that our arguments for including women do not overlook other groups like nonbinary and gender nonconforming people, and that we do not ignore the reality of intersectional identities. Women who do not belong to the majority race or who are not heterosexual may face additional barriers that compound with their gender identity and make being welcomed into the industrial design community even more difficult.

Research connecting gender and industrial design can also fall into the trap of essentializing gender. For example, a recent study attempted to use EEG to measure gender differences in design cognition (Vieira et al., 2021). As motivation for the

study, the researchers said they wanted to know whether the practice of design was influenced by gender, yet the authors did not provide a theoretical reasoning for why they thought that gender was an appropriate variable to use in this way. The paper also stated that “women less often than men have outstanding creative achievements” (Vieira et al., 2021, p. 572). Instead of looking for “gender differences” in brain activation to explain observations like this, we should be seeking to understand why our society counts men’s “creative achievements” as more “outstanding” than women’s. Furthermore, a recent review on brain research suggests that rather than a male-female binary or even a male-female continuum, “non-binary” is a better way to understand the brain. Human brains are comprised of a “mosaic” of male and female characteristics, and sex category only explains a small part of variability in brain structure (Joel, 2021, p. 1).

Industrial design has a history of designing around an “ideal” male user’s body. Dreyfuss’ (1966) anthropometric charts, representing the foundation of human factors for design, proposed designing for the average male body size, or for a range that would accommodate 95% of men (Dreyfuss, 1966). This phenomenon is manifested in with cars, for example, which have historically been designed to be safest for the average male body shape and size. Regulatory requirements in the United States didn’t even require crash test dummies modeled after female bodies to be used at all until 2003 (Fu et al., 2021). While the push for inclusion of female bodies is valid, projects that focus on the way products ignore female bodies are often short-sighted in that they then go on to ignore a broader diversity of bodies by ignoring trans and intersex bodies (Prochner, 2014). Like gender, biological sex is also not a binary (Karkazis, 2019). While it is important to understand how social structures like gender shape the profession of industrial design, we should also be careful that we do not marginalize other groups in the process of attempting to improve equality.

Conclusions and recommendations for future research areas

I began this essay with a story of an Instagram post igniting a debate about whether women’s lower representation in industrial design was due to a lack of talent or due to discrimination. I then provided a review of the literature about gender and industrial design to present what research can tell us about the issue. None of the literature indicated that female design students or professionals don’t work hard enough or aren’t as “talented” as male designers. The reality is much more complicated, as gender is a very powerful concept that shapes the organization of society. Gender, as a structure of social relations which brings differences between bodies into social process, influences ideas about design and technology versus craft. At the same time, associations of technical skill shape our ideas about gender. Thus, it doesn’t make sense to discuss why there are fewer women in industrial design without interrogating bigger topics like the co-creation of gender and technology. Women have historically and presently been written-out of industrial design when the boundaries of the discipline are drawn to exclude areas where women have been more prominent, calling those areas “craft” instead of design.

What is considered “technical” is not an accident. Despite the clear ergonomic similarities between operating a sewing machine and operating a band saw or operating a drill and operating a hand-mixer, the skills of operating tools associated with men are considered technical, and the skills of operating tools associated with women are considered domestic, non-technical, or even “craft.” Although industrial design involves many other skills besides CAD, sketching, and model-making, these skills are highly valued and often highly emphasized in design education programs. Since some female students have reported being discouraged by entering CAD or machine shop classes

with less prior experience than their male classmates, instructors should keep this in mind and make sure the classes are welcoming to students of all backgrounds and baseline skill levels. In my own time studying in a design program, I observed that my shorter and smaller classmates, who tended to be women, could not get leverage to use some tools in the shop because the worktables were too tall. Some of the tools were also too large for their smaller hands. It is somewhat ironic that education programs like industrial design, which often teach subjects like human-centered design and ergonomics, also house spaces where many of the students face poor ergonomic conditions that limit their ability to perform their assigned work. Furthermore, educators should take care to avoid exclusively promoting “masculine” sketching styles or assigning projects topics that are perceived as masculine. In reality, there are many styles of sketching that can communicate design concepts clearly, and industrial designers work on all kinds of projects in the real world, not just projects from domains associated with men.

Arguments for including women in the industrial design profession often bring up the fact that women are the primary decision makers in over 50% of the purchases of home furnishings, automobiles, and consumer electronics (Silverstein & Sayre, 2009). While design teams benefit from being more diverse, women have much more to offer design teams beyond being able to understand female consumers. We cannot essentialize gender in our arguments for the inclusion of women. This would mean saying things like “we need women on design teams because they are better at empathizing with the user.” People are not defined by their gender, and though patterns of socialization often mean women are trained and rewarded for more social behaviors, truly anyone of any gender has the capability of gaining any skill.

Ultimately, creating diverse design teams is critical because a diversity of experience will bring about a better ability to make decisions which account for the diversity

of users who the products will serve. We should ask questions like: how might our definition and standards of “good design” be gender and culturally biased? Or how might the focus on a “hot sketch” or “sexy render” be acting as a gatekeeper that values certain “technical” skills over the wide variety of other design skills which are critical to making a product successful? Future research in industrial design should focus on social factors that may be preventing historically excluded individuals, whether that be women, nonbinary people, minoritized racial groups, people with disabilities, or LGBTQIA+ individuals from thriving in industrial design education and professional sphere. Future research should also explore the issues of gender in design in other regions, such as Latin America and Africa, as cultural and regional differences likely impact the issue as well.

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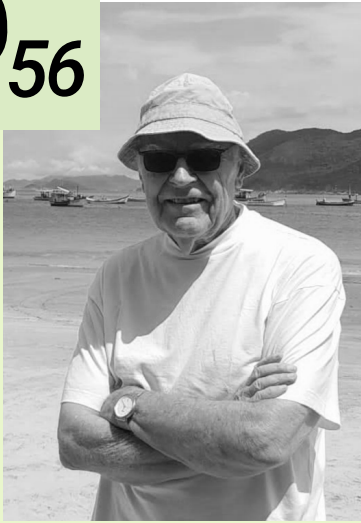
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Gui Bonsiepe

Realizó sus estudios de diseño de información en la prestigiosa HFG Ulm, Alemania, durante el periodo comprendido entre 1955 y 1959. Desde entonces, ha desempeñado una destacada labor en el ámbito del desarrollo, la investigación y la enseñanza hasta el cierre de dicha universidad. A partir de 1968, ha ejercido como diseñador y consultor especializado en políticas industriales en diversas naciones de América Latina, entre las que se destacan Chile, Argentina y Brasil. En busca de una continua superación profesional, dedicó los años 1981 a 1983 a una especialización en diseño de interfaces en una reconocida empresa de software en California. De igual manera, durante el periodo comprendido entre 1993 y 2003, impartió clases como catedrático en el campo del diseño de interfaces en la Universidad de Ciencias Aplicadas en Colonia. Actualmente, reside y desarrolla su labor profesional en Brasil y Argentina, consolidando así su vasta trayectoria internacional.

Agenda política de diseño? | Political agenda of design?

VERSIÓN ORIGINAL / ORIGINAL VERSION

Mientras que durante décadas el diseño solía tener una modesta existencia al margen de las disciplinas académicamente aprobadas, hoy el término “diseño” goza de una asombrosa diversidad de significados, refiriéndose no tanto a nuevos tipos de artefactos (en el sentido antropológico) sino a la manera de enfocar el diseño: Diseño Emocional / Diseño Experiencial / Diseño Transaccional / Diseño Transformacional / Diseño Crítico / Diseño Socialmente Responsable / Diseño Inclusivo / Diseño Especulativo / Diseño Participativo / Diseño Verde / Diseño Centrado en el Ser Humano / Ecodiseño / Diseño Inteligente (smart design)/ Diseño Inmaterial / Diseño Descolonial / Diseño Contrahegemónico / Diseño Anticipatorio / Diseño Cognitivo / Diseño de autor/a ...

Ahora bien, esta creciente diversidad podría considerarse un signo de vitalidad y dinamismo. Pero también refuerza una preocupación, pues el diseño como área con identidad propia puede verse socavada y diluida, hasta que todo puede llamarse “diseño” - lo que no sería un problema, si uno no se olvida de la esencia del diseño que es el proyecto, es decir la intervención concreta en la realidad.

¿Cómo se explica esta ampliación de las maneras de crear un lazo con el diseño? ¿Es algo más que una moda pasajera? ¿Por qué el término “diseño” ejerce una atracción tan fuerte mientras anteriormente, durante décadas, llevó una existencia marginal en el mejor caso reducida a la estética de “cosas bonitas y efímeras”? Las ciencias sociales y culturales parecen ser particularmente sensibles al nimbo del “diseño”.

Una razón para la aparición de nuevos tipos de enfoques de diseño podría estar relacionada con las limitaciones y contradicciones de la práctica y la enseñanza del diseño en el mercado global. Una de las fuerzas motrices de diseño es el deseo de crear sistemas viables desde el punto de vista ecológico y social, y la convicción que el diseño puede ser una actividad socialmente relevante y esto significa ir más allá de lo promovido por los think tanks como formadores dominantes del discurso, es decir fábricas de doctrinas.

Se pueden diferenciar dos tipos de diseño: Diseños orientados a responder a necesidades, en contraste con los diseños orientados al mercado. La dimensión política de los proyectos no surge de un acto de práctica individual engagé sino de un amplio proceso político-social que da el sostén de esta práctica. La sensibilidad subjetiva desempeña, en el mejor de los casos, un papel secundario.

A veces, estos deseos por un proyecto socialmente relevante se expresan explícitamente: ¿Cómo puede el diseño cambiar la sociedad? Evidentemente, una pregunta tan ambiciosa corre el riesgo de cargar sobre los hombros de la disciplina unas expectativas desproporcionadas y, por tanto, de limitarse a declaraciones verbales y manifiestos. Hoy en día, el lugar que una vez ocupaban las grandes narrativas se ha llenado con lo que podríamos llamar micronarrativas (y hasta small talk de los chats de las redes sociales). Las profesiones están inmersas en relatos sobre lo que son. Evolucionan y están expuestas a contradicciones. Y lo que es más importante, crean una realidad (en lugar de limitarse a reflejarla). En esta dinámica de relatos los discursos ganan y pierden relevancia.

La inclusión del diseño en una agenda política puede prestarse a malentendidos, por ejemplo, en igualar el interés político-social con una postura comprometida dentro del marco de ideas programáticas en forma de una doctrina con aspiración

hegemónica, corriendo el riesgo del fundamentalismo esencialista. Mas bien el diseño puede ser entendido como una fuerza mediadora entre intereses públicos y privados. Era este el planteo por ejemplo del conocido diseñador Jan van Toorn. El actuó como profesional y docente contra las tendencias autoritarias que socavaban las tradiciones democráticas con su promesa incumplida de participación y emancipación. Contra viento y marea -especialmente contra el abrumador poder corporativo y la instrumentalización del diseño como herramienta de marketing- logró mantener la esperanza en la viabilidad de una práctica y una tradición autodeterminada del diseño.

Manteniendo la dimensión política del discurso del diseño como el ámbito en el que se despliega la dinámica dialéctica entre poder y emancipación, el periodo actual ha sido etiquetado como post-utópico en franca oposición al proyecto moderno. La fuerza motriz de la modernidad consistió en la apuesta en el potencial del desarrollo en el sentido más amplio, social, industrial, tecnológico, económico, cultural, científico-, en beneficio de la humanidad. Ya a finales de los años sesenta, Tomás Maldonado insistió en la necesidad de incluir criterios ecológicos en la enseñanza del diseño. Esta postura programática del proyecto moderno no ha perdido relevancia. La disposición a considerar cómo cambiar las relaciones sociales existentes sigue siendo no sólo deseable, sino necesaria.

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ENGLISH TRANSLATION

Whereas for decades design used to have a modest existence on the fringes of academically approved disciplines, today the term “design” enjoys an astonishing diversity of meanings, referring not so much to new types of artifacts -in the anthropological sense- but to the way design is approached: Emotional Design/ Experience Design/ Transactional Design/ Transformational Design/ Critical Design/ Socially Responsible Design/ Inclusive Design/ Speculative Design/ Participatory Design/ Green Design/ Human-Centered Design/ Eco-design / Intelligent Design/ Immaterial Design/ Decolonial Design/ Counterhegemonic Design/ Anticipatory Design / Cognitive Design/ Author Design.

On the one hand, this growing diversity could be considered a sign of vitality and dynamism. However, it also reinforces a concern, as design as a field with its own identity can be undermined and diluted, to the point where everything can be called “design” - which would not be a problem, if one does not forget the essence of design, which is the PROJECT, that is, actual intervention in reality.

How can the variety of approaches to design be explained? Is it merely a fleeting phenomenon or does it have deeper significance? For years, the term “design” was confined to a minimal role at best and was primarily associated with aesthetic appeal of “beautiful objects”. The social and cultural sciences seem to be particularly attracted by the aura of “design”.

One reason for the emergence of new types of design approaches could be related

to the limitations and contradictions of design practice and teaching in the global market. One of the driving forces of design is the desire to create ecologically and socially viable systems, and the conviction that design can be a socially relevant activity, which means going beyond what is promoted by think tanks as dominant discourse-shapers, that is, doctrine factories.

Two types of design can be differentiated: Needs driven design in contrast to market-driven design. The political dimension of projects does not arise from an individual engagé attitude, but from a broad political-social process that supports this practice. Subjective sensitivity plays, at best, a secondary role.

Sometimes, these aspirations for a design project with social significance are explicitly stated: How can design bring about change in society? Clearly, such an ambitious question risks overburdening the discipline with disproportionate expectations and thus limiting itself to verbal statements and manifestos. Today, the place once occupied by great narratives is filled with what we might call micro-narratives (and even small talk in social media chats). Professions are immersed in stories about what they are. They evolve and are exposed to contradictions. And more importantly, they create a reality (rather than just reflecting it). In this dynamic of narratives, discourses gain and lose relevance.

Including design in a political agenda can lend itself to misunderstandings, for example, by equating political-social interest with a committed position within the framework of programmatic ideas in the form of a hegemonic doctrine, running the risk of essentialist fundamentalism. Rather, design can be understood as a mediating force between public and private interests. This was the proposal, for example, of the well-known designer Jan van Toorn. He carried out his duties as a professional and educator in opposition to authoritarian trends that threaten democratic traditions and their unfulfilled commitment to

participation and liberation. Despite the challenges, particularly against the formidable influence of corporate power and the commercialization of design as a promotional tool, he was able to preserve the belief in a self-directed practice and tradition of design.

Understanding the political dimension of the design discourse as the sphere in which the dialectic dynamics between power and emancipation unfolds, the current period has been labeled as post-utopian in frank opposition to the modern project. The primary driving force behind modernity was the confidence in the potential of comprehensive development, encompassing social, industrial, technological, economic, cultural, and scientific progress, with the aim of improving the human condition. Already six decades ago In the late 1960s, Tomás Maldonado emphasized the need for ecological considerations to be integrated into design education and professional practice, a programmatic stance that remains relevant to this day. The readiness to consider how change existing social relations remains not only desirable, but necessary.

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Giuseppe Bonsiepe pursued his studies in information design at the prestigious HfG Ulm, Germany, from 1955 to 1959. Since then, he has made significant contributions in the fields of development, research, and teaching until the university's closure. Starting in 1968, he has worked as a specialized designer and consultant in industrial policies across various Latin American countries, notably Chile, Argentina, and Brazil. In his quest for continuous professional growth, he dedicated the years from 1981 to 1983 to specialize in interface design at a renowned software company in California. Similarly, from 1993 to 2003, he served as a professor in interface design at the University of Applied Sciences in Cologne. Presently, he resides and pursues his professional endeavors in Brazil and Argentina, thus solidifying his extensive international career.

Articolo di ricerca | Research article

Arumã-Artigianato, Innovazione e Identità | *Arumã- Handicraft, Innovation and Identity*

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Sommario

Considerare la dimensione culturale nel percorso dello sviluppo sostenibile può essere una strategia interessante per la valorizzazione del territorio, per salvaguardare la diversità e per l'avanzamento economico e sociale di città e comunità tradizionali. L'intervento del design nel contesto della produzione artigianale può favorire lo sviluppo di prodotti innovativi che valorizzano la cultura e la tradizione locale, promuovendo rapporti sinergici e sistemici che accolgono e sostengono le comunità indigene. In questo scenario, l'articolo analizzerà il rapporto tra design e cultura locale attraverso la descrizione di un caso studio realizzato nell'Amazzonia in particolar modo riportando le esperienze di collaborazione tra designer locali e artigiani indigeni al fine di creare una linea di nuovi prodotti per stimolare la generazione di reddito e la produzione sostenibile di prodotti artigianali. Come risultato è stata creata una collezione di gioielli connotati da una forte carica culturale amazzonica, sviluppata sulla base dei principi di progettazione sostenibile nella disciplina del design, come l'uso del metodo "Material Driven Design". Il progetto ha dimostrato che la sinergia tra artigianato e design è capace di contribuire al mantenimento e alla valorizzazione della cultura e dei territori; anche se, è importante tenere in considerazione le questioni etiche nel rapporto con le comunità tradizionali, pensare a strategie di produzione e servizi legati al prodotto e alla possibilità di nuovi prodotti e materiali utili alla società che non entrino in conflitto con il patrimonio culturale millenario di questi gruppi.

Parole Chiave: Sviluppo del prodotto; design sostenibile; materia prima rinnovabile; design e cultura del territorio; artigianato indigeno; Amazzonia.

Abstract

Considering the cultural dimension in the path of sustainable development can be an attractive strategy for the development of the territory, the safeguard of the diversity and the enhancement of the economic and social conditions of traditional communities. The

employment of the notions in the field of design in the context of artisanal production can foster the development of innovative products that embrace the local culture and traditions, as well as promote synergistic and systemic relationships in which indigenous communities can take an active part. In this scenario, the article will attempt to analyze the relationship between design and local culture, reporting a case study carried out in the Amazon. In this study, a collaboration between local designers and indigenous artisans was born, especially to create new sustainable products that could provide a stable income for the indigenous artisans. A collection of jewelry characterized by a strong Amazonian cultural charge was developed in compliance with sustainable design principles, such as the use of the “Material Driven Design” method. Although it is important to consider the ethical issues when dealing with traditional communities, plan to production and services strategies product-related, to think about a new products and materials that are useful to the society without undermining the millennial heritage held by these groups, it is possible to conclude that a synergy between craftsmanship and design can contribute to the enhancement of culture and territories.

Keywords: Product development; design sustainable; renewable raw material; design and territory culture; indigenous handicraft; Amazon.

Introduzione

In senso lato, la cultura è presente nella scrittura, nella lingua, nell'architettura, nella gastronomia, negli strumenti, nelle abilità, nella tecnologia, nella conoscenza, nei costumi, nell'arte, ecc. Quando si parte dal concetto di patrimonio culturale, lo si divide in beni materiali (come gli edifici, il territorio ed altri) e in beni immateriali (come la storia, la comunicazione, i servizi, la fruizione del prodotto, la conservazione ecc.). Il concetto di patrimonio è simile al concetto di territorio in quanto include la vita delle persone e il modo in cui progettano e utilizzano i loro manufatti, considerando gli elementi della cultura autoctona - materiali e immateriali, la memoria e il senso di appartenenza - come una trama che unisce i vari ambiti locali (cultura, natura, tradizione, etnografia, storia, architettura, religione, lingua) (Oliveira & Krucken, 2015; Sun, 2022; Brenna et al., 2020; Cabrero & Ochoa, 2016).

La cultura influisce direttamente nel modo in cui l'uomo vede il mondo e il suo rapporto con esso ed è, quindi, molto difficile pensare alla sostenibilità senza considerare la dimensione culturale. Oltre a essere una dimensione importante per la sostenibilità, la cultura è diventata anche il punto chiave nell'economia mondiale;

le pratiche innovative basate sulla cultura sono percepite come una delle risorse più affidabili per l'avanzamento economico di città e territori. Attraverso le metodologie presenti nella disciplina di design è possibile realizzare prodotti capaci del esprimere l'essenza dei luoghi, strutturare una strategia efficace capace di promuovere e valorizzare il patrimonio culturale di un territorio (Ferrara, 2016; Lin, 2022; Myerson, 2017; Sun, 2022; Aparo, 2013).

In questo contesto il design può muoversi in due direzioni: può sviluppare nuovi prodotti/servizi-sistemi ispirati da una cultura specifica, un processo che Sun (2022) definisce “from Function to Feeling” (dalla funzione al sentimento), o può migliorare prodotti/servizi-sistemi già esistenti e realizzati da un artigiano o da un gruppo all'interno di un territorio, modalità che Sun (2022) descrive come “Inspiration from culture, and ideation from the product” (ispirazione dalla cultura e sviluppo del prodotto). In termini di ricerca accademica, spicca il progetto “Sistema Design Italia” del 1998, coordinato dal Professore Ezio Manzini. Nella ricerca è stata messa in luce la dimensione territoriale del design italiano e le sue declinazioni territoriali, rivelando i punti di forza, le

specificità e i segni più innovativi per ogni area del paese. In sintesi, il design può essere applicato non solo con l'obiettivo di migliorare i prodotti culturali locali, ma anche come mezzo per migliorare i servizi e i sistemi legati a quel prodotto, quali le risorse legate all'ambiente, il patrimonio storico e culturale e l'immaginario collettivo legato all'idea di luogo. In questo modo, le forme avviano un dialogo con i luoghi di origine, rinnovando e riconfigurando indirettamente il territorio stesso (Parente, 2016).

L'artigianato attraverso i propri lavori rivela le tradizioni e le caratteristiche di un popolo. L'opera di artigianato è una manifestazione culturale in quanto incorpora i valori legati al contesto regionale, alla conoscenza culturale e alle sue pratiche. I saperi, i processi e le tecniche sono riconosciuti come Patrimonio Culturale Immateriale (Stefanidi et al., 2022; Mourão, 2019). Dal punto di vista della sostenibilità, possiamo considerare l'artigianato ecocompatibile se enfatizza la lavorazione manuale e l'uso di materiali naturali e rinnovabili (UNESCO, 2023). Quando si parla di sostenibilità nella pratica dell'artigianato, i gruppi che si distinguono maggiormente sono le popolazioni indigene in quanto l'insieme di conoscenze e di pratiche di questi popoli evidenziano l'armonia tra ambiente e comunità umane. Questo approccio può essere un percorso interessante per una produzione sostenibile, capace di contribuire allo sviluppo della scienza e della tecnologia moderna (Lin, 2022).

Al giorno d'oggi l'industrializzazione e la globalizzazione hanno messo a dura prova l'artigianato tradizionale. La produzione su larga scala, che spesso fornisce beni di prima necessità a un costo inferiore, compete direttamente con l'artigianato. Oltretutto, l'uso smodato delle risorse disponibili e il cambiamento climatico compromettono la reperibilità delle materie prime necessarie per la produzione artigianale. Un'altra problematica importante è il disinteresse della popolazione più giovane nei confronti dell'artigianato perché lo considera estremamente laborioso e per lo scarso tornaconto economico. Un'altra

criticità legata alle tradizioni artigianali è la dinamica dei "segreti di produzione", in virtù della quale l'insieme delle conoscenze e delle pratiche sarebbero a uso esclusivo di un singolo gruppo o di una singola comunità e per tale motivo rischiano di essere dimenticate (UNESCO, 2023; Li et al., 2021).

In tal senso, la necessità di salvaguardare la diversità e i caratteri identitari connaturati alla dimensione artigianale è una forma di mitigazione degli effetti della globalizzazione, un segno di resistenza contro un fenomeno che ha minato i saperi tradizionali e il saper fare. La diversità culturale è il frutto di un lungo processo di evoluzione che ha avuto luogo all'interno di determinati territori (Follesa, 2013). Tale aspetto risulta particolarmente importante se lo si rapporta al crescente interesse dimostrato nei confronti dell'artigianato tradizionale, come segno di controtendenza e di risposta all'urbanizzazione e all'industrializzazione. Molte persone in tutto il mondo sono arrivate ad apprezzare gli oggetti artigianali in quanto reificazione di conoscenze e valori culturali (UNESCO, 2023).

In questo contesto, emerge il cosiddetto "consumo etico" nella scelta di prodotti o servizi, atteggiamento basato sulla consapevolezza delle questioni ambientali, della giustizia sociale, della promozione del commercio equo e solidale (Martins, 2020). Si profila un nuovo tipo di consumatore moderno consapevole di come la scelta per prodotti e servizi rispecchi i valori sociali, culturali e ambientali associati alla produzione locale di partenza. Questo nuovo bacino di consumatori cerca prodotti con valore identitario, riconoscendo in esse il valore di un sapere ancestrale tramandato e perfezionato di generazione in generazione (Lin, 2022).

Risulta essenziale, quindi, dover riflettere sul rapporto tra artigianato e design, in particolar modo focalizzandosi sulla necessità di attuare pratiche volte a migliorare i prodotti artigianali, valorizzare la cultura e la tradizione locale, nonché incentivare attività che stimolino la capacità creativa degli artigiani e l'interesse dei più giovani a mantenere tale

tradizione in vita. In questo scenario cresce il ruolo dei designer in comunità o in gruppi di produzioni artigianali il cui obiettivo è quello di collaborare allo sviluppo di prodotti adatti ai nuovi bisogni del mercato. L'intervento del design nel contesto della produzione artigianale può favorire lo sviluppo di prodotti innovativi e promuovere rapporti sinergici e sistemici che abbracciano le comunità indigene. Tali rapporti sono, inoltre, terreno fertile per la configurazione di modelli di sostenibilità ambientale, economica e sociale (Mourão, 2019; Souza, 2015).

Attraverso il design per la specificità territoriale è possibile formulare un linguaggio progettuale che abbia alla base un rapporto diretto con le risorse materiali e immateriali di un luogo; una nuova retorica capace di realizzare un processo di re-identificazione con i luoghi e di riappropriazione dei saperi. Il design si presenta come uno strumento cruciale per definire la strategia di valorizzazione del patrimonio tradizionale perché analizza, valuta e interpreta i diversi fattori culturali. In tal senso, nell'ambito della progettazione, non si parte mai da zero ma da una complessa rete di segni, materiali, tecniche e usi, che costituiscono il tessuto culturale di ogni territorio e che sono il punto di partenza per lo sviluppo di nuove espressioni (Follesa, 2013; Aparo, 2013).

È necessario, tuttavia, che il designer accolga la sfida di tradurre e interpretare correttamente le caratteristiche della cultura locale come un fattore differenziale e competitivo, senza interferire con il suo significato reale; è importante promuovere la vera identità del luogo di origine del prodotto (Mourão, 2019). Nel rapporto tra progettista e comunità/artigiano è fondamentale seguire gli strumenti normativi internazionali che tutelano i diritti umani e i diritti dei popoli indigeni. Sulla base di tali considerazioni, nel 2015 il Comitato intergovernativo ha elaborato dodici principi etici per la protezione del patrimonio culturale immateriale al fine di garantirne la sopravvivenza. Questi principi guidano le buone pratiche per i governi, per le organizzazioni e per i singoli individui che influiscono direttamente o indirettamente su tale patrimonio (UNESCO, 2023).

Sulla base di quanto esposto, l'articolo analizzerà il rapporto tra design e cultura locale attraverso la descrizione di un caso studio realizzato nello stato di Amazonas in Brasile, in particolar modo riportando le esperienze di collaborazione tra designer locali e artigiani indigeni. La cooperazione ha avuto come risultato la creazione di nuovi prodotti realizzati con l'Arumã (*schnosiphon arouma Korn*), una *marantaceae* perenne e molto abbondante, tipica della foresta amazzonica. Come materia prima naturale e rinnovabile, tale pianta è largamente impiegata dalle popolazioni indigene per la produzione di setacci, ceste, tappeti e accessori, realizzati con la tecnica tradizionale della fibra intrecciata. Inoltre, gli oggetti in Arumã rappresentano una fonte di reddito importante per le famiglie locali (Matsuno, 2000; Marques, 2009; Marques, 2015; Rios, 2011).

Metodologia

Verrà descritto il progetto di creazione di nuovi prodotti realizzati con l'Arumã, frutto della collaborazione tra due istituzioni che operano nello stato di Amazonas, Brasile: FUCAPI- Fondazione, Centro di Analisi e Ricerca e Innovazione e SEBRAE/AM- Servizio Brasiliano di supporto all'imprenditore.

Nel progetto, FUCAPI è stata responsabile della creazione di nuovi prodotti, sviluppati dal team di progettazione del dipartimento del "Design Tropicale dall'Amazzonia", composto da un mentor designer, tre product designer e due graphic designer. Il dipartimento della fondazione FUCAPI è specializzato nello sviluppo di manufatti che valorizzino l'identità regionale e la cultura amazzonica, ed esaltino tecniche, manodopera locale e materie prime regionali. Il principale obiettivo di questo dipartimento è fornire un'alternativa di sviluppo sostenibile per la regione. Mentre, l'istituto SEBRAE, attraverso il suo dipartimento di artigianato, sostiene gli artigiani dell'Amazonas nello sviluppo della filiera produttiva e nell'introduzione dei loro prodotti nel mercato. Nel progetto l'obiettivo del dipartimento è stato quello di rendere questa filiera di artigiani sostenibile,

nonché di fornire la struttura e il sostegno logistico necessario ai designer per il loro primo rapporto con gli artigiani locali.

Al fine di creare una linea di nuovi prodotti per la valorizzazione della cultura dei popoli autoctoni dell'Amazzonia, per stimolare la generazione di reddito e la produzione sostenibile di prodotti artigianali, il progetto è stato articolato in tre fasi. Nella prima fase è stata effettuata una ricognizione generale della filiera di produzione. Nella seconda fase è stato organizzato un workshop per lo scambio di conoscenze tra artigiani e designer. Nell'ultima fase sono stati sviluppati nuovi prodotti sulla base dei principi di progettazione ecosostenibile nella disciplina del design, come l'uso del metodo di progettazione "Material Driven Design" (MDD) e dello storytelling come strumento di comunicazione.

La ricognizione è stata effettuata da un designer di prodotto e da un designer grafico nella città di São Gabriel da Cachoeira- SGC, a 850 km da Manaus, capitale di Amazonas la cui concentrazione di popolazione indigena è la più alta del Brasile (Artesol, 2022; Portal Amazônia, 2022). La città di SGC è stata scelta per lo stretto rapporto con il SEBRAE, per la grande diversità culturale e per il ricco patrimonio materiale e immateriale. In questa regione i prodotti sono realizzati con i materiali più disparati, tutti reperibili nella foresta e trasformati in cesti di fibre, utensili in ceramica, bio gioielli in sementi, oggetti in legno. Tali prodotti documentano la cultura e la storia di ogni tribù indigena e sono testimonianza di tecniche ancestrali reinterpretate in maniera originale (Foirn, 2022).

Nella stessa fase, sono state raccolte informazioni *in loco* attraverso l'osservazione dei processi produttivi, le registrazioni fotografiche, le interviste e le conversazioni informali. È stato possibile seguire il processo di produzione artigianale sviluppato da diversi popoli indigeni, soprattutto quelli che vivono nell'area urbana. Per cinque giorni i designer hanno incontrato due gruppi di artigiani e un artigiano indipendente che hanno presentato i loro prodotti, i loro usi e i loro significati.

Il primo gruppo visitato è stato l'ASSAI (Associazione degli Artigiani Indigeni di São Gabriel da Cachoeira), formato da indigeni di varie etnie, che hanno prodotto cesti e accessori realizzati con la fibra della foglia della palma amazzonica Tucum (*Bactris Setosa*) e con l'uso di tinture naturali di vari colori. La seconda visita è stata fatta all'artigiano indipendente Duda Gonçalves, appartenente all'etnia Kubeo, che produce setacci, cestini, borse e gioielli (Figura 1). Tali oggetti sono realizzati con la fibra di Arumã e vengono creati attraverso un intreccio delicato e simmetrico, simile a un tessuto con disegni grafici sobri. Vengono anche utilizzate tinte naturali nei colori nero e rosso (ONIC, 2022).



Figura 1. Artigianato Baniwa e Coripaco. (b) Artigianato Kubeo (Ricardo, 2014; Mouco, 2022).

Il terzo incontro è stato organizzato con la comunità Areal, composta da un gruppo di artigiani indigeni, la cui maggioranza è appartenente al gruppo etnico Coripaco. Il gruppo realizza grandi cesti e setacci decorati con motivi grafici colorati e stravaganti intrecciando la fibra di Arumã (Figura 1). È stato possibile osservare il processo di lavorazione in tutte le sue fasi: verniciatura, rimozione della fibra, processo di intrecciatura (Figura 2). Gli indigeni che lavorano l'Arumã utilizzano unicamente la parte esterna del fusto della pianta, la cui superficie piana e flessibile permette il taglio di strisce dell'ordine del millimetro. Per separare la parte esterna del fusto dalla parte interna gli indigeni utilizzano, con movimenti precisi, un coltello con il quale effettuano dei piccoli tagli ricavando delle strisce sottili. Successivamente, inizia

il processo di intreccio, svolto con rigorosa simmetria che si traduce in oggetti dalle *texture* più diverse. Si possono creare motivi grafici colorati tingendo anticipatamente le strisce con coloranti naturali.



Figura 2. Processo di estrazione della fibra di Arumã e lavorazione artigianale (Ricardo, 2014; Mouco, 2022).

La principale applicazione per i popoli indigeni della specie Arumã è nel settore dell'artigianato che, al di là della valenza economica, ha un elevato valore simbolico e una grande carica culturale. Ad esempio, per i Baniwa, i tradizionali cesti realizzati in Arumã rappresentano un'arte antica: tale gruppo ritiene che l'arte dell'intrecciatura sia stata trasmessa dagli Dei agli uomini della tribù baniwa. Le rappresentazioni grafiche presenti sui manufatti derivano da incisioni rupestri degli antenati e rappresentano un mezzo utile per preservare la memoria dei saperi passati. Ogni *texture* e disegno grafico racconta una storia e racchiude un significato legato alla cultura di ciascun popolo indigeno (Ricardo, 2014; Marques, 2009).

Tutte le informazioni raccolte dai due designer in SGC sono state presentate al resto del team a Manaus e analizzate in base al peso culturale, alla qualità della produzione, all'innovazione, al rischio di scomparsa e alla disponibilità di materie prime. Sulla base di tali parametri, il candidato scelto per il progetto è stato l'artigiano Kubeo, Duda Gonçalves. La sua abilità, la qualità dei suoi prodotti, la sua tecnica peculiare di lavorazione dell'Arumã, tramandata di generazione in generazione unicamente dalla sua famiglia, spiccano

rispetto agli altri gruppi di artigiani e la materia prima con cui lavora è perenne e molto abbondante nell'Amazzonia (Matsuno, 2000; Marques, 2009).

Per la seconda fase del progetto è stato utilizzato il "Material Driven Design" (MDD), un metodo di sviluppo del prodotto che ha come punto di partenza un particolare materiale (Karana et al., 2015). Il metodo prevede quattro fasi: la comprensione del materiale (caratteristiche tecniche ed esperienziali), la creazione di un'esperienza visiva con il materiale, lo sviluppo di modelli visivi per l'esperienza creata e la progettazione di materiali e concetti di prodotto (Mota, 2021). Sulla base del metodo MDD si è tenuto un workshop di 5 giorni, svolto all'interno dell'istituzione FUCAPI con la partecipazione dell'artigiano Kubeo e del team di sei designer. In questa occasione è stato possibile approfondire le tecniche e le finiture realizzate dall'artigiano che ha presentato 3 tipi di intreccio (percorso di formiche, foglia di palma e diamante) (Figura 3). Inoltre, l'artigiano ha impiegato tre tipi di rifiniture: la rifinitura con filo e resina per fissare l'intreccio, la rifinitura con filo di fibra morbida di Tucum per una lavorazione più raffinata e sicura e la rifinitura con vite e legature che aiutano a strutturare i cestelli e i setacci.

I designer hanno proposto l'inserimento di nuovi materiali e l'utilizzo di tinture industriali che facilitassero il processo produttivo e valorizzassero ulteriormente il lavoro

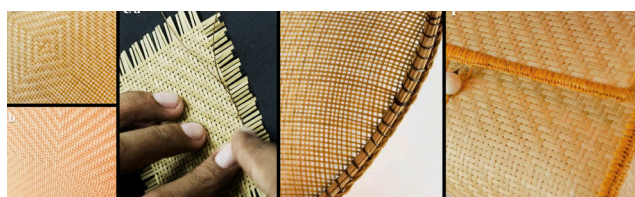


Figura 3. Tipi di intreccio: (a) diamante, (b) foglia di palma, (c) percorso di formiche. Tipi di rifinitura: (d) con filo e resina, (e) con vite e legature, (f) con filo di fibra morbida-

artigianale (Figura 4). Il primo esperimento ha previsto l'utilizzo del filo di rame nella trama di Arumã: i fili di rame sono stati tagliati alla stessa lunghezza delle fibre per poi essere posizionati in sequenza (una fibra di Arumã, un filo di rame e così via), e, infine, essere intrecciati manualmente.

Nella fase iniziale, il processo ha presentato delle difficoltà ma ben presto l'artigiano ha acquisito dimestichezza col nuovo materiale. Il filo di rame ha dato maggiore struttura all'intreccio rendendo, inoltre, più resistente la creazione finale. Il metallo ha messo in risalto anche i diversi intrecci realizzati dall'artigiano, rendendone più evidente la trama.

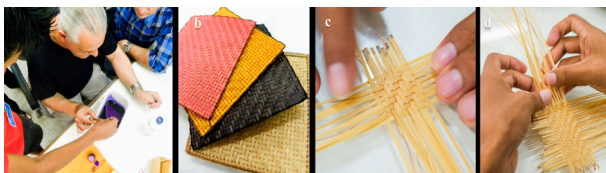


Figura 4. (a,b) Esperimento con aniline di origine industriale e (c,d) introduzione del filo di rame nella trama di Arumã (Mouco, 2022).

Per quanto riguarda la tintura, sono state utilizzate le aniline, coloranti concentrati in polvere da sciogliere in alcool etilico di origine industriale, per donare maggiore varietà di colori rispetto alle sole tinture tradizionali in rosso e nero impiegate dagli indigeni. Si è osservato che l'Arumã assorbe bene la tintura e la nuova *palette* di colori conferisce ai manufatti un aspetto più moderno. Tuttavia, nel lungo termine si è notato che le tinture in aniline tendono a sbiadirsi più rapidamente rispetto ai coloranti di origine naturale tradizionalmente impegnati. Dopo questo scambio di conoscenze, i designer sono passati all'ultima fase del progetto per sviluppare nuovi prodotti.

Risultati

Secondo Cabrero & Ochoa (2016), il designer è in grado di far congiungere lo studio dell'estetica con la percezione di un territorio specifico. Egli sarebbe capace di comprendere come le esperienze locali possano tramutarsi in segni e simboli spesso codificati in elementi di design. In questo modo, è possibile vivere un territorio specifico attraverso un oggetto. Con questa premessa è stata sviluppata la terza e ultima fase del progetto di creazione della linea di prodotti impiegando le antiche tecniche di intrecciatura dell'Arumã degli indigeni Kubeo. È stata realizzata una collezione di gioielli chiamata "Arumã" (Figura 5), composta da 9 set, comprendenti collane,

orecchini, bracciali. Le forme geometriche dei pezzi mettono in risalto l'intrecciatura dell'Arumã e rimandano a motivi grafici utilizzate per i cesti tradizionali indigeni.

È stata utilizzata la tecnica dell'artigiano Kubeo con i 3 tipi di intrecci tradizionali (percorso di formiche, foglia di palma, diamante). I materiali impiegati spaziano dai filamenti in rame, ai pezzi in argento, alle placcature in oro rosso e ai cordini in pellame. L'unione con questi materiali conferisce alla fibra dell'Arumã lo *status* di gioiello. Nel processo di prototipazione, tutte le tele di Arumã sono state tessute dall'artigiano sulla base di misure definite dal designer. Per richiamare la trama delle finiture utilizzate per i cesti dei Kubeo, ma reinterpretata in chiave moderna, i designer hanno progettato delle collane con rifiniture simili a quelle tradizionali ma sono stati impiegati i filamenti di rame e cordini di pelle. Le parti in argento sono state realizzate con tecniche di oreficeria artigianale sulla base di disegni tecnici preparati dai designer. L'assemblaggio dell'argento con l'Arumã è avvenuto tramite montaggio.

Un altro punto particolarmente interessante è stato lo sviluppo del materiale grafico (Figura 5), importante strumento di comunicazione per la collezione, che ha contribuito notevolmente alla diffusione e alla comprensione del lavoro svolto. I due designer grafici hanno creato un catalogo contenente la descrizione dell'intera collezione, le foto dei set, del processo produttivo e dello sviluppo della collezione, registrati durante la fase di ricognizione a SGC e durante il workshop a Manaus. Inoltre, all'interno del catalogo sono state inserite copertine contenenti grafiche ricavate dalle forme geometriche scelte per la realizzazione di ciascun set (quadrato, rettangolo, trapezio, triangolo, rombo, cerchio). L'uso dello *storytelling* nella presentazione dei prodotti è stato un importante strumento di comunicazione perché capace di mettere in contatto i consumatori col territorio di origine e col patrimonio culturale e il ruolo identitario dei prodotti (Chan, 2021).

Dopo la pubblicazione del catalogo, la collezione è stata presentata in mostre di

diverse regioni del Brasile. È stata, inoltre, avviata la commercializzazione dei set sia in Brasile che in altri Paesi. La collezione è stata premiata a livello internazionale e ha contribuito alla diffusione della cultura amazzonica e della tecnica dell'intreccio coll' Arumã dei Kubeo. Ha dato visibilità all'artigiano e ottenuto un riscontro positivo da parte del pubblico. Sono seguiti, pertanto, lo sviluppo di altri prodotti realizzati con i medesimi materiali e tecniche (oggetti, borse e gioielli), favorendo il rapporto con l'industria e l'innovazione.

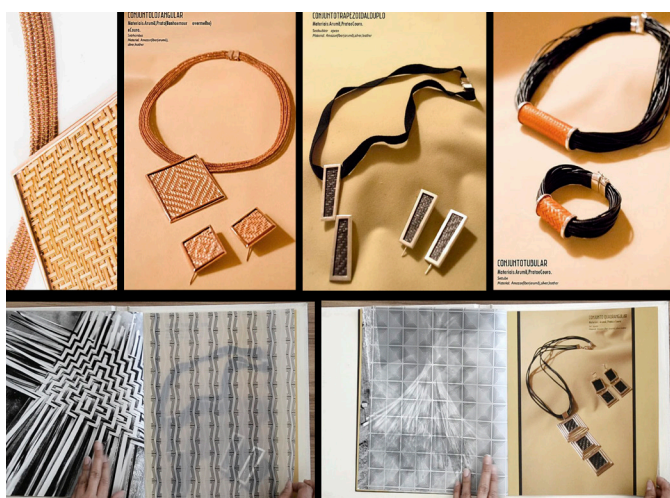


Figura 5. (a) Collezione di gioielli Arumã e (b) catalogo (Mouco, 2022).

Conclusioni

Attraverso questo progetto è stato possibile verificare il livello di gradimento dell'artigianato indigeno da parte del pubblico più ampio. I prodotti artigianali, connotati da una forte carica culturale amazzonica, hanno un alto potenziale e si distinguono dagli altri prodotti presenti nel mercato. Tuttavia la produzione su bassa scala non la rende adatta al mercato che privilegia catene di produzione più ampie. È stato evidenziato come fosse necessario ripensare le strategie di produzione e di distribuzione in risposta ai modelli di consumo del grande mercato o considerare nuovi modelli di consumo.

Incoraggiare un rapporto più stretto tra design e artigianato è la strategia necessaria per salvaguardare e valorizzare la cultura e il territorio. È indispensabile svolgere un

lavoro approfondito, eticamente giusto e nel rispetto dei valori del singolo artigiano e delle comunità tradizionali in generale.

Sulla base dell'esperienza con la fibra di Arumã e con la prospettiva di favorire un approccio più sostenibile all'artigianato risulta importante, in primo luogo, pensare a prodotti che non entrino in competizione con il retaggio millenario detenuto dalle popolazioni indigene e, infine, contemplare le opportunità offerte dall'utilizzo degli scarti di Arumã nello sviluppo di un nuovo biomateriale sostenibile in linea con i principi della economia circolare.

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FUCAPI- Fondazione, Centro di Analisi e Ricerca e Innovazione (Manaus-Amazonas-Brasile). Nel progetto, FUCAPI è stata responsabile della reazione di nuovi prodotti, sviluppati dal team di progettazione del dipartimento del “Design tropicale dall’Amazzonia”, composto da un mentor designer, tre product designer e due graphic designer. Il dipartimento della fondazione FUCAPI è specializzata nello sviluppo di manufatti che valorizzino l’identità regionale e la cultura amazzonica, nonché che esaltino tecniche, manodopera locale e materie prime regionali. Il principale obiettivo di questo dipartimento è fornire un’alternativa di sviluppo sostenibile per la regione. SEBRAE/AM-Servizio Brasiliano di supporto all’Imprenditore

(Manaus-Amazonas-Brasile)

l’istituto SEBRAE, attraverso il suo dipartimento di artigianato, sostiene gli artigiani dell’Amazonas nello sviluppo della filiera produttiva e nell’introduzione dei loro prodotti nel mercato. Nel progetto l’obiettivo del dipartimento è stato quello di rendere questa filiera di artigiani sostenibile, nonché di fornire la struttura e il sostegno logistico necessario ai designer per il loro primo rapporto con gli artigiani locali.

Mostre

Showroom Design Tropical da Amazonia / Showroom Design Tropicale dell’Amazzonia-Amazonas/ Brasile (2014- 2016)

Paralela Gift- São Paulo/ Brasile (2015)

São Paulo Fashion week - São Paulo/ Brasile (2016 e 2017)

MICSUL- Mercado das Indústrias Criativas e Culturais do Sul / Mercato delle industrie creative e culturali del Sud - Bogotá/ Colombia (2016)

Design Weekend- São Paulo/ Brasile (2017)

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Premi

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Premio nazionale-- Objeto Brasileiro/ Oggetto

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Arumã-Handicraft, Innovation and Identity | *Arumã-Artigianato, Innovazione e Identità.*

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Abstract

Considering the cultural dimension in the path of sustainable development can be an attractive strategy for the development of the territory, the safeguard of the diversity and the enhancement of the economic and social conditions of traditional communities. The employment of the notions in the field of design in the context of artisanal production can foster the development of innovative products that embrace the local culture and traditions, as well as promote synergistic and systemic relationships in which indigenous communities can take an active part. In this scenario, the article will attempt to analyze the relationship between design and local culture, reporting a case study carried out in the Amazon. In this study, a collaboration between local designers and indigenous artisans was born, especially to create new sustainable products that could provide a stable income for the indigenous artisans. A collection of jewelry characterized by a strong Amazonian cultural charge was developed in compliance with sustainable design principles, such as the use of the "Material Driven Design" method. Although it is important to consider the ethical issues when dealing with traditional communities, plan to production and services strategies product-related, to think about a new products and materials that are useful to the society without undermining the millennial heritage held by these groups, it is possible to conclude that a synergy between craftsmanship and design can contribute to the enhancement of culture and territories.

Keywords: Product development, design sustainable, renewable raw material design and territory culture, indigenous handicraft, Amazon.

Sommario

Considerare la dimensione culturale nel percorso dello sviluppo sostenibile può essere una strategia interessante per la valorizzazione del territorio, per salvaguardare la diversità e per l'avanzamento economico e sociale di città e comunità tradizionali. L'intervento del design

nel contesto della produzione artigianale può favorire lo sviluppo di prodotti innovativi che valorizzano la cultura e la tradizione locale, promuovendo rapporti sinergici e sistemici che accolgono e sostengono le comunità indigene. In questo scenario, l'articolo analizzerà il rapporto tra design e cultura locale attraverso la descrizione di un caso studio realizzato nell'Amazzonia in particolar modo riportando le esperienze di collaborazione tra designer locali e artigiani indigeni al fine di creare una linea di nuovi prodotti per stimolare la generazione di reddito e la produzione sostenibile di prodotti artigianali. Come risultato è stata creata una collezione di gioielli connaturati da una forte carica culturale amazzonica, sviluppata sulla base dei principi di progettazione sostenibile nella disciplina del design, come l'uso del metodo "Material Driven Design". Il progetto ha dimostrato che la sinergia tra artigianato e design è capace di contribuire al mantenimento e alla valorizzazione della cultura e dei territori; anche se, è importante tenere in considerazione le questioni etiche nel rapporto con le comunità tradizionali, pensare a strategie di produzione e servizi legati al prodotto e alla possibilità di nuovi prodotti e materiali utili alla società che non entrino in conflitto con il patrimonio culturale millenario di questi gruppi.

Parole Chiave: Sviluppo del prodotto, design sostenibile, materia prima rinnovabile, design e cultura del territorio, artigianato indigeno, Amazzonia.

Introduction

In a wide sense, culture permeates the writing, the language, the architecture, the gastronomy, the tools, the skills, the technology, the customs, the art, etc. We can divide the concept of cultural heritage into two major branches: the material goods (such as buildings, the territory and others) and immaterial goods (such as history, communication, services, use of the product, conservation, etc.). The idea of heritage is similar to the idea of territory in that it considers people's life stories as well as how they create and utilize their objects. The elements of local culture - tangible and intangible, memory, and the sense of belonging - entwine with each other and create a web that unites the various local scopes (the culture, the nature, the tradition, the ethnography, the history, the architecture, the religion, the language) (Oliveira & Krucken, 2015; Sun, 2022; Brenna et al., 2020; Cabrero & Ochoa, 2016).

Culture directly affects the way man sees the world and his relationship with it and it is therefore very difficult to think of sustainability without considering the cultural dimension. In addition to being a crucial aspect, culture has also become a key factor in the world economy: innovative

practices based on culture are perceived as one of the most reliable resources for the economic advancement of cities and communities. Through the tools provided by the discipline of design, it is possible to create products capable of expressing the essence of places. Indeed, it's possible to employ an effective strategy capable of promoting and enhancing the territory's cultural heritage (Ferrara, 2016; Lin, 2022; Myerson, 2017; Sun, 2022; Aparo, 2013).

In this context, design can move into two directions: it can develop new products/services/systems inspired by a specific culture, a process that Sun (2022) defines as "from Function to Feeling", or it can improve existing products/services/systems created by a craftsman or group within a territory, a method that Sun (2022) describes as "Inspiration from culture and ideation from the product". In these regards and in terms of academic research, the project "Sistema Design Italia" of 1998, coordinated by Professor Ezio Manzini, stands out. The research highlighted the territorial dimension of Italian design and its territorial declinations, revealing the strengths, specificities and the most innovative signs for each area of the country.

In summary, design can be applied not only with the aim of enhancing local cultural products, but also to improve services and systems related to that product, such as resources related to the environment, historical and cultural heritage and the collective imagination associated to the idea of place. In this way, the setting could initiate a conversation with the origins while simultaneously indirectly renewing and reconfiguring the area. (Parente, 2016).

The craftsmanship, through its productions, reveals the traditions and the features of a people. As it combines values relating to the regional context, cultural knowledge, and its practices, the piece of craftsmanship serves as a cultural display. Knowledge of the processes and techniques involved, are recognized as Intangible Cultural Heritage (Stefanidi et al., 2022; Mourão, 2019). From the perspective of sustainability, we can define handicrafts as eco-friendly only if they emphasize manual processing and the use of natural and renewable materials (UNESCO, 2023). The indigenous peoples are the ones who stand out the most in terms of regards sustainability in the practice of craftsmanship because their knowledge and customs emphasize the harmony between the natural world and human populations. This formulation can be an interesting path to sustainable production, capable of contributing to the development of modern science and technology (Lin, 2022).

Nowadays, industrialization and globalization have put a strain on traditional handicrafts: large-scale manufacturing, often providing necessities at a lower cost, directly competing with craftsmanship. Moreover, the excessive exploitation of available resources and its aftermath, climate change, compromise the availability of the raw materials necessary for artisanal production. Another important problem is the indifference of the younger population towards craftsmanship because they consider it extremely laborious and incapable of steady income. Another critical issue linked to craft traditions is the phenomenon of “production secrets”, by

virtue of which the set of knowledge and practices would be for the exclusive use of a single group or a single community and for this reason they risk being forgotten (UNESCO, 2023; Li et al., 2021).

In this sense, the safeguard of diversity and of the peculiar characteristics embedded in the artisan dimension can be a form of mitigation of the effects of globalization, a sign of resistance against a phenomenon that has undermined traditional knowledge and know-how. Cultural diversity is the result of a long process that took place within specific territories (Follesa, 2013). This point is especially important in considering the rising interest in traditional craftsmanship, which is seen as a powerful countertrend to urbanization and industrialization. Many people around the world have come to appreciate craftsmanship as a reification of cultural knowledge and values (UNESCO, 2023).

In this context, a new attitude based on the awareness of environmental issues, on social justice and on the promotion of fair trade in the choice of products or services emerges: the so-called “ethical consumption” (Martins, 2020). A new type of modern-day consumer shows up and is aware of how the choice of products and services reflects the social, cultural and environmental values associated with the initial local production. This new type of consumer is looking for products imbued with identity, because in them is synthesized ancestral knowledge handed down and perfected from generation to generation (Lin, 2022).

It is therefore essential to reflect on the relationship between craftsmanship and design, in particular by focusing on the need to implement practices aimed at improving artisan products, enhancing local culture and tradition, as well as encouraging activities that stimulate the creative ability of craftsmen and the interest of the youngest to keep this tradition alive. In this setting, the role of designers in communities or groups of artisanal productions is growing. The objective is to collaborate in the development of products suitable for the

new needs of the market. The involvement of design in the context of artisan production can foster the development of innovative products and promote synergistic and systemic relationships that embrace indigenous communities. Furthermore, these relationships are a major hotbed for the configuration of environmental models and economic and social sustainability (Mourão, 2019; Souza, 2015).

Through the design that highlights territorial specificity it is possible to formulate a code capable of waving a direct relationship with the material and immaterial resources of a place, a new rhetoric capable of carrying out a process of re-identification with a specific place and re-appropriation of a corpus of knowledge. Design presents itself as a crucial tool for defining a traditional heritage enhancement strategy because it analyses, evaluates and interprets the various cultural factors. In this sense, in a project that involves design and craftsmanship, the designer has access to a complex network of signs, materials, techniques and uses, which constitute the cultural framework of each territory and this must be the starting point for the development of products/services/systems (Follesa, 2013; Aparó, 2013).

However, it is necessary for the designer to accept the challenge of correctly translating and interpreting the characteristics of a local culture as a differential and competitive factor, without interfering with its real meaning. It is also important to promote the true identity of the product's origin place (Mourão, 2019). In the relationship between designer and community/artisan is essential to follow the international regulatory instruments that protect human rights and the rights of indigenous peoples. Based on these considerations, in 2015 the Intergovernmental Committee elaborated twelve ethical principles for the protection of intangible cultural heritage in order to guarantee its survival. These principles pinpoint the best practices for governments, organizations and individuals who directly or indirectly influence this heritage (UNESCO, 2023).

Based on the foregoing, the article analyzes the relationship between design and local culture through the description of a case study carried out in the state of Amazonas in Brazil, in particular by reporting the experiences of collaboration between local designers and indigenous artisans. The cooperation resulted in the creation of new products made up from Arumã (schnosiphon arouma Korn), a perennial and very abundant marantaceae, typical of the Amazon rainforest. As a natural and renewable raw material, this plant is widely used by indigenous populations. With the traditional technique of woven fiber, they produce sieves, baskets, carpets and accessories. Furthermore, objects in Arumã represent an important source of income for local families (Matsuno, 2000; Marques, 2009; Marques, 2015; Rios, 2011).

Methodology

In the following paragraph will be described the project aimed to create new products made with the fiber of Arumã, carried out by two institutions operating in the state of Amazonas, Brazil, the FUCAPI- Foundation, Center for Analysis and Research and Innovation and the SEBRAE/AM- Brazilian Entrepreneur Support Service.

In the project, FUCAPI was responsible for the creation of new products, namely a team of designers in its department of "Tropical Design from the Amazon", made up of a mentor designer, three product designers and two graphic designers. The department specializes in the development of artifacts that can promote regional identity and Amazonian culture, as well as enhance local labor and regional raw materials. The main objective of this department is to provide a sustainable and alternative means of development for the region. Meanwhile, the SEBRAE/AM institute with its craft department supports the artisans of Amazonas in the improvement of their production chain and manages the introduction of their products to the market. In the project, the craft department's objective was to make this sustainable

supply chain, as well as to provide the facility and logistical support necessary for the designers during their first contact with local artisans.

In order to create a line of new products that could enhance the indigenous people's culture of the Amazon, as well as stimulate the sustainable production of handicraft products capable of bringing about a good economic income, the project was divided into three phases. During the first phase, a general survey of the production chain was carried out. In the second phase, a workshop was organized for the exchange of knowledge between craftsmen and designers. In the last phase, new products were developed based on the principles of sustainable design, such as the employment of the "Material Driven Design" (MDD) method and the storytelling as an effective communication tool.

The survey was carried out by one product designer and one graphic designer in the city of São Gabriel da Cachoeira (SGC), 850 km from Manaus, the capital of Amazonas whose concentration of indigenous population is the highest in Brazil (Artesol, 2022; Portal Amazonia, 2022). The city of SGC was chosen due to its close relationship with SEBRAE, great cultural diversity and rich tangible and intangible heritage. In this region items are made with the most diverse materials, all found in the forest and skillfully transformed into baskets, ceramic utensils, biojewels, wooden objects. These products represent the culture and history of each indigenous tribe and bear witness to ancestral techniques reinterpreted in an original way (Foirn, 2022).

In the same phase, in loco data was collected through the observation of production processes, photographic recordings, interviews and informal conversations. It was possible to follow the artisanal production process developed by different indigenous people, especially those living in the urban area. For five days the designers met two groups of artisans and an independent craftsman who presented their products, their uses and their meanings.

The first group visited was the ASSAI (Association of Indigenous Artisans of São Gabriel da Cachoeira), made up of indigenous people of various ethnic groups, who produced baskets and accessories made up from the fiber of the Amazon palm tree Tucum (*Bactris Setosa*) and with the usage of natural dyes in various colors. The second visit was made to the independent craftsman Duda Gonçalves, belonging to the Kubeo ethnic group, who produces sieves, baskets, bags and jewelry (Figure 1). Such objects are made with Arumã fiber and are created through exquisite and symmetrical weaving, like a textile with sober graphic designs. Natural dyes are also used in hues of black and red (ONIC, 2022).



Figure 3. Baniwa e Coripaco handicrafts. (b) Kubeo handicrafts (Ricardo, 2014; Mouco, 2022).

The third meeting was arranged with the Areal community made up of an indigenous artisans' group, the majority of which belong to the Coripaco ethnic group. The group makes large baskets and sieves decorated with colorful and extravagant graphic motifs by weaving the Arumã fiber (Figure 1). It was possible to observe the working process in all its phases: the varnishing, the fiber removal, the braiding process (Figure 2). The natives who work the Arumã use only the external part of the plant stem, whose flat and flexible surface allows the cutting of strips of few millimeters. To separate the external part of the stem from the internal section the natives use, in precise movements, a knife with which they make small cuts obtaining thin strips. Subsequently, the weaving process begins,

carried out with rigorous symmetry which results in objects with the most precise and diverse textures. Colorful graphic patterns can be created by pre-dying the stripes with natural dyes.



Figure 4. *Arumã fiber extraction process and handicrafts* (Ricardo, 2014; Mouco, 2022).

For the indigenous people, the main Arumã application is in the handicraft sector which, beyond the economic value, has a high symbolic value and a great cultural charge. For example, for the Baniwa, the traditional baskets made up from the Arumã represent an ancient art: this group believes that the art of weaving has been transmitted by the Gods to the male members of the Baniwa tribe. The graphic representations on the handicrafts derive from petroglyphs of the ancestors and represent a useful means of preserving the memory of past knowledge. Each texture and graphic design tell a story and contains a meaning linked to each indigenous people culture (Ricardo, 2014; Marques, 2009).

All the information gathered by the two designers in SGC was presented to the rest of the team in Manaus and analyzed according to the cultural weight, the quality of the production, the degree of innovation, the risk of disappearance and the availability of raw materials. Based on these parameters, the candidate chosen for the project was the Kubeo craftsman, Duda Gonçalves. His skill, the quality of his products, his peculiar technique of processing Arumã handed down from generation to generation only by his family, stand out compared to other groups of craftsmen and the raw material

with which he works is perennial and very abundant in the Amazon (Matsuno, 2000; Marques, 2009).

For the second phase of the project, the “Material Driven Design” (MDD) method was used, a product development method that has a particular material as its starting point (Karana et al., 2015). The method involves four phases: the material understanding (technical and experiential characteristics), creating a visual experience with the material, development of visual models for the created experience, the design of materials and product concepts (Mota, 2021). Based on the MDD method, a five-day workshop was held within the FUCAPI institution with the participation of the craftsman Kubeo and the team of six designers. On this occasion it was possible to learn more about the techniques and finishings created by the craftsman who presented three types of weaving (ant trail, palm leaf and diamond) (Figure 3). Furthermore, the craftsman used three types of finishes: the finishing with thread and resin to fasten the weave, the finishing with soft Tucum fiber thread for a more refined and safer workmanship and the finishing with vines and bindings that give structure to baskets and sieves.

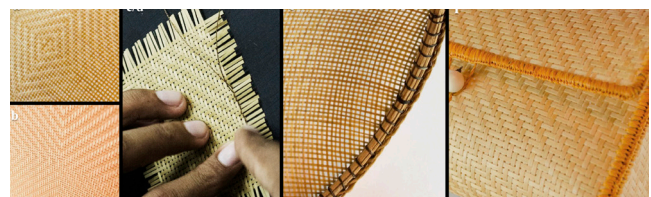


Figure 5. *Types of weaving: (a) diamond, (b) palm leaf, (c) ant trail. Types of finishing: (d) with thread and resin, (e) with vines and bindings, (f) with soft fiber thread (tucum)* (Mouco, 2022).

The designers proposed the inclusion of new materials and the use of industrial dyes that would facilitate the production process and further enhance the handicrafts (Figure 4). The first experiment involved the employment of copper wire in the Arumã weave: the copper wires were cut to the same length as the fibers and then positioned in sequence (one Arumã fiber, one copper wire and so on), and finally were woven manually. In the initial phase,

the process presented some difficulties, but the craftsman soon became familiar with the new material. The copper wire gave greater structure to the weave and made the final creation more resistant. The metal has also highlighted the different patterns made by the craftsman by making the texture more evident.

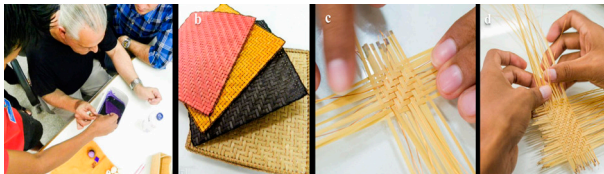


Figure 6. (a, b) Experiment with anilines of industrial origin and (c, d) and the intertwining of the copper wire in the Arumã weave (Mouco, 2022).

As for the dye, anilines (concentrated powder dyes to be dissolved in ethyl alcohol of industrial origin) were used to give a greater variety of colors than the traditional red and black dyes used by the natives. It has been observed that Arumã absorbs dye well and the new color palette gives the artefacts a more modern look. However, over the long term it has been noted that aniline dyes tend to fade more quickly than traditionally used dyes of natural origin. After this exchange of knowledge, the designers moved on to the last phase of the project, the development of new products.

Results

According to Cabrero & Ochoa (2016), the designer is able to unify aesthetic's aspects with the perception of a specific territory. He should be able to understand how local experiences have been and will be turned into signs and symbols often codified in an element of design. In this way, it is possible to experience a specific territory through an object. On this premise, the third and final phase of the product line creation was formulated using the ancient Arumã weaving techniques of the Kubeo indigenous people. A jewelry collection called "Arumã" was created (Figure 5) and consists in nine sets, including necklaces, earrings, bracelets. The geometric shapes

of the pieces highlight the Arumã weaving and resemble the graphic motifs used for traditional indigenous baskets.

The technique with the 3 types of traditional weaving (ant trail, palm leaf, diamond) of the Kubeo craftsman was used. The materials used ranged from copper threads to silver pieces, to red gold plating, to leather cords. The pairing with these materials gives the Arumã fiber the status of a jewel. In the prototyping process, all Arumã fabrics were woven by the craftsman based on measurements defined by the designer. To recall the texture of the finishings used for the Kubeo baskets, but reinterpreted in a modern key, the designers have conceived necklaces with finishings similar to the traditional ones but using copper threads and leather cords. The silver parts were made with artisan goldsmith techniques based on technical drawings prepared by the designers. The assembly of the silver with the Arumã was done by assembly.

Another interesting point was the development of the graphic material (Figure 5), an important communication tool for the collection, which has greatly contributed to the public exposure and understanding of the work carried out. The two graphic designers have created a catalogue containing the description of the entire collection, photos of the sets, the production process and the development of the collection recorded during the survey at SGC and during the workshop in Manaus. Furthermore, covers containing graphics obtained from the geometric shapes chosen for the creation of each set (square, rectangle, trapezoid, triangle, rhombus, circle) have been included in the catalogue. The use of "storytelling" in product presentation has been a significant communication strategy because it allows consumers to connect with their native land and cultural heritage (Chan, 2021).

After the catalogue was published, the collection was displayed in several exhibitions in different regions of Brazil. The marketing of the sets was also launched in Brazil and in other countries. The collection has been awarded internationally e has

contributed to the diffusion of Amazonian culture and the technique of weaving with Arumã of Kubeo. It gave visibility to the craftsman and obtained a positive response from the public. For these reasons, other products made with the same materials and techniques (objects, bags, and jewels) were created, improving the relationship with industry and innovation.

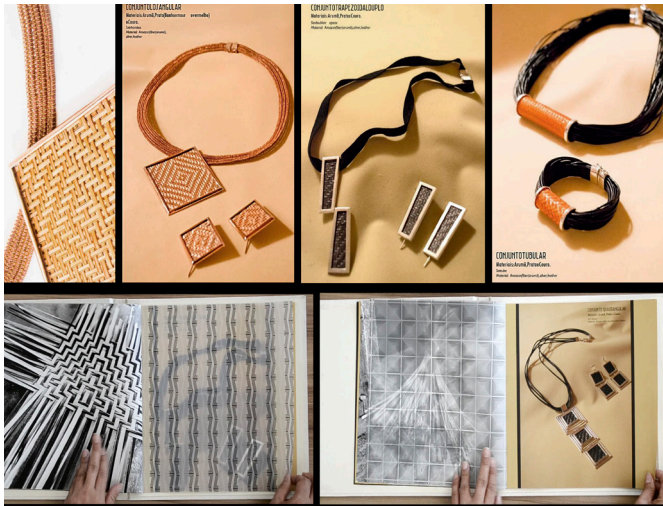


Figure 7. (a) Set of Jewelry "Arumã" e (b) catalogue (Mouco, 2022).

Conclusion

Through this project was possible to verify the level of appreciation of indigenous craftsmanship by a wider public. The handcrafted products with a strong Amazonian cultural charge have a high potential and stand out from the other products on the market. However, the small-scale production makes it unsuitable for a market that prefers larger production chains. It has been highlighted how it was necessary to rethink the production and distribution strategies in response to the consumption models of the large market and to consider new consumption models.

Promoting a deeper relationship between design and handicraft is an essential method for preserving and enhancing culture and territory. It is essential to carry out an in-depth work, ethically fair and respectful of the values of the individual craftsman and of traditional communities.

Based on the experience with Arumã fiber and with the prospect of promoting a more sustainable approach to craftsmanship, it is important, on one hand, to think of products that do not scathe the millennial heritage held by indigenous peoples; and on the other hand, to look at the opportunities offered by the use of Arumã waste in the development of a new sustainable biomaterial in line with the principles of the circular economy.

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FUCAPI. Foundation, Center for Analysis and Research and Innovation (Manaus-Amazonas-Brazil).

In the project, FUCAPI was responsible for the creation of new products, namely a team of designers in its department of “Tropical Design from the Amazon”, made up of a mentor designer, three product designers and two graphic designers. The department specializes in the development of artifacts that can promote regional identity and Amazonian culture, as well as enhance local labor and regional raw materials. The main objective of this department is to provide a sustainable and alternative means of development for the region.

SEBRAE/AM. Brazilian Entrepreneur Support Service (Manaus-Amazonas-Brazil).

SEBRAE/AM institute with its craft department supports the artisans of Amazonas in the improvement of their production chain and manages the introduction of their products to

the market. In the project, the craft department’s objective was to make this sustainable supply chain, as well as to provide the facility and logistical support necessary for the designers during their first contact with local artisans.

Exhibitions

Showroom Design Tropical da Amazonia/ Amazonian Tropical Design Showroom- Amazonas/ Brazil (2014– 2016)

Paralela Gift- São Paulo/ Brazil (2015)

São Paulo Fashion week- São Paulo/ Brazil (2016 and 2017)

MICSUL- Mercado das Indústrias Criativas e Culturais do Sul/ Southern creative and cultural industries market- Bogotá/ Colombia (2016)

Design Weekend- São Paulo/ Brazil (2017)

Vogue Fashion Night Out- Amazonas/ Brazil (2017 and 2018)

Brasil Plural, Arte Brasileira/ Brazil Plural, Brazilian Art-Nantes/France (2019)

Design Oriundi- São Paulo/ Brazil (2020)

Awards

Internacional- Objeto Brasil/ Brazil Object - São Paulo/ Brazil (2016)

Nacional- Objeto Brasileiro/ Brazilian Object - São Paulo/ Brazil (2016)

proyecta 56

An industrial design journal



Review | Revisión

Approaches and Technologies for the Human-Centered Industry 5.0. | Enfoques y tecnologías para la industria 5.0 centrada en el ser humano.

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ABSTRACT

A little less than a decade after the emergence of Industry 4.0 in the industrial world, the new paradigm 5.0 is gaining ground, which is simultaneously reflected in the definition of a smart society. In fact, we are witnessing an innovative transition that defines the pace of technological, but also economic and social change. Starting from the innovations of the fourth industrial revolution and from the study of reference guidelines of European Commission (2021) Industry 5.0 "repositions" technologies completely at the service of people and the whole of humanity. The research aims to identify and explore the points of contact and implementations arising from the transition from paradigm 4.0 to the human-centric approach 5.0. Through a comparative analysis of case studies and best practices in the industrial field it is possible to frame and define the future scenarios of manufacturing that see human and machine synchronized and synergistically working together to improve the efficiency of production.

Keywords: digital transformation; enabling technologies; User Centered Design; Industry 5.0; Human factors; Industrial Design.

Resumen

Poco menos de una década después de la aparición de la Industria 4.0 en el mundo industrial, gana terreno el nuevo paradigma 5.0, que se refleja simultáneamente en la definición de una sociedad inteligente. De hecho, asistimos a una transición innovadora que define el ritmo del cambio tecnológico, pero también económico y social. A partir de las innovaciones de

la cuarta revolución industrial y del estudio de las directrices de referencia de la Comisión Europea (2021), la Industria 5.0 “reposiciona” completamente las tecnologías al servicio de las personas y de toda la humanidad. La investigación pretende identificar y explorar los puntos de contacto y las implementaciones derivadas de la transición del paradigma 4.0 al enfoque centrado en el ser humano 5.0. A través de un análisis comparativo de estudios de casos y mejores prácticas en el ámbito industrial es posible enmarcar y definir los escenarios futuros de la fabricación que ven al ser humano y a la máquina trabajando sincronizados y sinérgicamente para mejorar la eficiencia de la producción.

Keywords: Transformación digital; Tecnologías facilitadoras; Diseño Centrado en el Usuario; Industria 5.0; Factores humanos; Diseño Industrial

Introduction

What we are living is certainly the new era of manufacturing in which we have come to the full awareness of how enabling technologies are the basis of the competitiveness of companies on the international market and of the improvement in terms of productivity.

Through the widespread diffusion of innovation and thanks to the continuous updating of production technologies, the factory is experiencing a renewal with positive effects on the health of production operators. (Formati et al., 2021)

Starting from the study of the document entitled “Industry 5.0 - Towards a sustainable, human-centric and resilient European industry” (European Commission, 2021) it is possible to highlight the main axes that have been identified by the European Union for the definition of Industry 5.0: human-centricity, sustainability and resilience.

In detail, from the transformation of industrial spaces into safe and inclusive environments and through the satisfaction of needs, we are witnessing a change in the role of the user “positioned” at the center of production processes to implement levels of psycho-physical well-being. Moreover, sustainable evolution represents the further pillar of the new industrial context through the use of renewable sources, the reuse of energy and the reduction of energy waste. Finally, another founding element of Industry 5.0 (European Commission, 2021) is represented by resilience, referring to the need to develop industrial contexts

increasingly robust and adaptive to new needs. Industry 5.0 is not necessarily to be understood as an evolutionary continuation of its predecessor 4.0, but as an extension of the main features and essential factors designed to place future industry in the new society. (Xu et al., 2021)

Also, in the previously mentioned document, the European Commission identified the six main technological axes 5.0: personalized human-computer interaction, technologies inspired by nature and intelligent materials, digital twin, technologies for data transmission, storage and analysis, artificial intelligence and finally technologies for energy efficiency, renewable energy, energy storage and autonomy. In the past, the interaction between the user and the technologies has been analyzed from different perspectives, addressing the capabilities, limitations of the operator and machines to define the criteria for automating process tasks and completely replacing industrial operators (Winter et al., 2014).

The European Commission (2020) defines the technologies that support the concept of Industry 5.0: human-centric solutions and human-machine-interaction; bio-inspired technologies and smart materials; real time based digital twins and simulation; cyber safe data transmission, storage, and analysis technologies; artificial Intelligence; and technologies for energy efficiency and trustworthy autonomy.

Starting from the knowledge of such “tools”, as also argued by Xu et al. (2021), some of the 4.0 technologies will help to achieve the social and economic goals of Industry 5.0. It will increasingly be used in the new Society to generate the new scenarios of innovation with the cooperation between humans, machines and technologies.

Industrial Evolution in Society 5.0

In today's industrial contexts, technologies, which have become accessible to all, are spreading at such a speed that the same transformations and innovations are taking place more rapidly than previously. Successive industrial revolutions have actually significantly transformed society by “altering” not only production systems, but also interactions between individuals and with their surroundings (Schwab, 2019).

As a matter of fact, Industry 4.0 was born as an evolution of the previous industrial revolutions: (i) the introduction of water and steam power to mechanize production, (ii) electricity for mass production and (iii) information and digital technology to increase automation levels by making use of electronic systems and Information Technology. The innovation pursues the strategy to generate products and services with radically new meaning and it represents the determining factor in the development of society and the advanced economies of nations.

With reference to production, Industry 4.0 has generated the increase in the product and services quality, together with the promotion of new business models, to fill the gaps about the current state of digitalization and in the competitive market perspective offered by new technologies. In particular, Industry 4.0 has “rethought” factories through the use of digital, as well as reconsidering the design approach and monitoring the production process in real time (Laudante & Caputo, 2016).

On the basis of the literature review, it is possible to assert now that Industry 4.0 has entered an advanced stage of maturity

after several years of development with reference to some technological factors. This does not mean that it is an outdated paradigm. On the contrary, it represents the natural step in which the new declination of the human-technology relationship is highlighted through the innovative Human Technology-Oriented approach. This approach triggers the futuristic vision of a new evolutionary stage in which human and machine reconcile and work in perfect symbiosis with each other (Longo et al., 2020).

Industry 5.0 represents the further technological transition that introduces the new role of modern industry in society. This new vision explains how technology succeeds in changing our lives and how technological innovations are capable of shaping the economic, social, cultural, and human scenarios in which we operate (Schwab, 2016).

Differently from Industry 4.0, considered as “Smart Manufacturing for the Future” (Demir et al., 2019), which mainly pursues the purpose of increasing productivity and reaching mass production using innovative technologies, Industry 5.0 will bring new challenges in human-machine interaction. This provides analysis and research in the area of human factors, recognizing in human welfare the main objective to achieve sustainability and social welfare and not only productivity.

It is more of a cultural revolution characterized by the inclusion of the resolution of production but also socio-environmental problems through the use of technologies considering people and the environment. This aims to ensure that the needs of current generations do not compromise those of future generations.

It is increasingly possible that Industry 5.0 will generate unprecedented innovation in human-machine interaction (HMI) starting from the increasing presence of machines in people's daily lives and the consequent demand for specific skills in the field of HMI and more generally in the computational analysis of human factors (Nahavandi, 2019).

Considering that technological progress cannot disregard the development of economic and social welfare, technology is understood as a means for change and hopefully the improvement of the entire society.

In fact, Industry 5.0 and Society 5.0 represent two related concepts that define in parallel the new paradigm not limited to manufacturing. This highlights the emergence of new broader societal challenges in which advanced technologies such as robots, artificial intelligence and augmented reality are actively employed in everyday life, generically to improve people's quality of life (European Commission, 2021).

The Society 5.0 Concept – introduced by the Japanese government back in 2016 – represents a vision of a future society guided by scientific and technological innovation. “Through an initiative merging the physical space (real world) and cyberspace by leveraging ICT to its fullest, we are proposing an ideal form of our future society: a Super-Smart Society that will bring wealth to the people”. The series of initiatives geared toward realizing this ideal society are now being further deepened and intensively promoted as “Society 5.0” (European Commission, 2021).

Society 5.0 is defined as the “Society of Intelligence” (Salgues, 2018), in which physical space and cyberspace are strongly integrated and in which innovation in science and technology occupies a fundamental role. It thus represents the new business model that focuses primarily on “intelligent” human-machine collaboration and therefore on the full synergy between human and artificial intelligence through the definition of new organizational models and acquisition of increasingly targeted skills.

The constant threat of human labor being replaced by machines will be replaced by increased sensitivity and attention to human well-being and the “protection” of one's mental and creative abilities, towards the promotion of a “Super Smart Society”. In this context, advanced technologies define

the profile of a new high-performance, “super-intelligent” and “human-centric” society through the promotion of innovation. The visionary idea is to use the new technologies in an intelligent, inclusive and responsible way aiming to improve living conditions, also in terms of health and safety in the workplace, as well as processes and products.

It will be appropriate to design the relationships between technologies, society and users in order to experiment with new ways of knowledge transfer through contemporary and innovative techniques and tools (Buono & Giugliano, 2021).

One of the characterizing factors of Industry 5.0 is represented by the human-centric approach in industry that puts human needs and requirements at the center of the process for defining the increased efficiency and production added value through the reduction of waste and associated costs. (H-UTokyo Lab., 2020)

In particular, the connection between human creativity and machine efficiency will guarantee the added value in new productions. It moves from a strongly machine-centric approach to a human-centric oriented “vision” that will increasingly take shape with the definition of systems that are more personalized and closer to the real needs of the user.

In accordance with Doyle-Kent & Kopacek (2019), each product 5.0 will be based on the real individual user needs by putting new technologies at the service of the population. This will make production more lean, automated, digital and data-driven by endowing the designer with more freedom. Realizing new products requires what can be called the “human touch” through human involvement and engagement, as reported by Østergaard (2018). He defines this process as a new mode of customization through the enhancement of creativity and the spirit of resilience as the main indications provided by the new 5.0 model (Ruffinoni, 2020).

In reference to personalization, a key point of the new “collaborative” industry, Maddikunta

et al. (2021) refer to the concept of “hyper personalization”. This model applies cutting-edge technologies to provide more specific products, services, and content to each user so that the integration of human intelligence with robots helps personalize production with minimal cost and maximum precision based on consumer needs and market changes.

The new anthropocentric approach in Industry 5.0

The industrialization process has led to the widespread use of machines that have steadily increased in number and complexity over time. In such contexts, the user and the machine interact through interactive tools designed to improve machine performance and to facilitate operator management and control. New forms of interaction with technology are being configured that require the user to have greater capacity and cognitive ability.

Since the beginning of industrialization, machine capabilities have increased and human control of processes has evolved from simple, with mechanization, to cognitive, with computerization, and emotional, with automation (Pacaux-Lemoine et al., 2017).

The transition to Industry 4.0 has seen the rise of cyber-physical systems and the introduction of digital technologies, technical, organizational and design changes, involving new forms of human-machine interaction and a new balance between physical and cognitive load. Overcoming these challenges will require the application of new user-centred design approaches that take into account physical, cognitive and sensory capabilities (Kadir & Broberg, 2021), putting the worker's needs and requirements at the center of the process. This moves from a technology-oriented to a human-centred approach (Xu et al., 2021).

The computational thinking process (Wing, 2006), i.e. the mental process of solving problems of various kinds through the

planning of strategies and execution logic, has driven the configuration of technologies and information technology over the last few decades. This process has made it possible to exploit the potential of machines as objects capable of compensating for human skills or inaccuracies. However, this approach implies inherent problems in the design of solutions to which the user must necessarily adapt. Conversely, anthropocentric design, and hence the study of human-machine interaction, aims to adapt product requirements and specifications to users. From these scenarios, the need for the integration of different disciplines emerges to configure new, effective and efficient solutions that can adapt and fulfil the user's needs.

In fact, according to the European Commission (2021), the important prerequisite for Industry 5.0 is that technology should serve people and therefore be adapted to the needs and diversity of workers in the industry. Therefore, it is necessary to change the design paradigm and place the focus on human factors and ergonomics requirements (Kadir & Broberg, 2021), to achieve the sustainable implementation of enabling technologies and promote the well-being of workers.

Based on these factors, it will be possible to design flexible and adaptable places, usable and on a human scale, according to a user-centered methodological approach – methodology sanctioned with ISO 9241-210:2019 “Ergonomics of human-system interaction” – in which the user becomes the center of the design phases. A crucial aspect in the design of systems and solutions introduced by Industry 4.0 has concerned the interface between people and the set of technologies implemented. This system has become increasingly complex and articulated to the point of making the concept of human-machine interface obsolete and reductive.

In the Factory of the Future, people no longer operate and interact with a single machine, but with a network of cyber-physical systems. These systems of physical and computational components

are decentralized, dynamic, open, and context-sensitive, constantly evolving, and which are intertwined with the mental and social worlds of the users, so much so that they are defined as cyber-physical-social (Assolombarda, 2020).

In this context, production operators acquire autonomy, and the working environment becomes more inclusive. To achieve this, the operators must be involved in the design and implementation of new enabling technologies. For example, the Factory 2Fit project aims to empower and involve operators in a connected industrial environment who are given greater influence and responsibility in shaping the production process, through virtual means. Early results from this project indicate a positive impact on productivity and worker well-being. Initiatives such as these make it possible to link increasing automation with human skills, thus strengthening the human-centered approach (European Commission, 2021).

The automation does not only concern the introduction of new intelligent machines able to interact with the environment, with other machines or with the operators, but it involves the radical change in the way of thinking about processes and workflows. In this way, it's possible envisage new ways of collaboration between human and machine and reconfiguring the activities of the Smart Factory (Leoni, 2019).

The design guided by the needs and physical-perceptual characteristics of the operators acquires relevance in the definition of working environments, defining the transition of design from technology-oriented to human-oriented. In the design phases, the focus is no longer exclusively on functional requirements and what is technically possible, but on the needs of the user. He is no longer forced to adapt the way he or she works to the product, but the latter is designed according to work preferences (Flaspöler et al., 2006).

A human-centered production system is characterized by the planning and implementation of the production process,

where the user is in control of the process and technologies, encouraging the use of human skills (Charles et al., 1990). An example of a human-centric workstation, anticipated already between 2018 and 2019 by the company Festo, can be identified in the “BionicWorkplace” system. This solution proposes a new working context of human-robot collaboration, where connection and safety guarantee new ways of working.

The workstation is ergonomically designed and all elements, right down to the lighting, can be configured, customized and adapted to suit the user. At the center of the production operator's field of vision is a projection screen that provides all the relevant information, dynamically displaying the content according to the activity in progress. Surrounding it, there are sensors and camera systems that constantly record the positions of the operator, components and tools. In this way, the user can interact directly with the “BionicCobot” and control it using movement, touch or voice command. The system recognizes operators and movements through the use of innovative clothing. By configuring intelligent workplaces that foster learning through the introduction of multifunctional tools, the collaboration between humans and machines will become increasingly intuitive, simple and efficient in the future.

Recent developments include the introduction of automation systems featuring technologies such as artificial intelligence, natural language processing, predictive analytics and robotics that define radical innovation at the workplace. Optimizing human-machine interactions will capitalize on the added value that production workers bring to the factory by developing innovative human-centered technologies. Industry 5.0 can support and empower, rather than replace, workers (European Commission, 2021) and technologies such as artificial intelligence will be able to redesign production activities where the added value will come from the operator's intellectual capabilities (Matsushima, 2017).

Indeed, according to Daugherty & James Wilson (2018), artificial intelligence frees up time, creativity and human capital, while work activities become less automatic. According to this view, technologies improve operator capabilities and support their activities. Examples of technologies that increase operators' performance are exoskeletons to support physical activities; augmented reality to transfer knowledge and increase cognitive abilities; wearable technologies to improve health through monitoring physiological conditions (Fantini et al., 2018).

The use of new wearable devices, integrated with virtual and augmented reality technologies, allows the development of applications or "scenarios" to support naturally and effectively innovative services useful to provide product, process and production progress information. This constitutes the technological basis for the development of digital environments. In such scenarios, every piece of information is at hand and every operation can be carried out in an optimized way, to reduce time and costs (Favetto et al., 2018).

However, the user is often regarded as one of the most unpredictable components of any system and an important, usually limiting, design parameter. Environments and products are used by users with multiple physical and dimensional characteristics and wide variations in strength and flexibility. The importance of investigating these variables has led manufacturers to consider user issues earlier in the design process. In fact, in many application areas, there is a strong need to model the physical elements of humans together with models of workplaces and equipment (Morrissey, 1998). The user governs and manages the production processes, and he must be able to monitor and interact with different machinery located within the factory. In order to do this, it is necessary to introduce a simple level of interaction and integrated involvement with the surrounding environment, using innovative and wearable devices. During work activities, the user must be able to interact with the industrial

context, the robots and the machines simply and intuitively, through hands, arms, eyes, voice.

Numerous research breakthroughs in neurophysiological and cognitive sciences have spurred a wave of research aimed at effectively linking human and mechanical intelligence capabilities, as well as matter and nature to access intelligence for the benefit of humanity. "NextMind", unveiled at CES 2020, is the world's first brain-sensing device that simultaneously enables the control of augmented reality or virtual reality viewers. The device sits at the back of the head and attaches to any AR/VR device, allowing interaction with virtual environments directly with brain control. The device has a control system that captures neurophysiological signals and transforms them into data to create real-time neuro-control capabilities. Artificial intelligence-based technologies are incorporated to decode user intent and translate neural signals into digital commands, transmitted via Bluetooth technology.

According to Lu et al. (2021) through natural human-machine communications, including empathic understanding, anthropocentric production will become possible, converting current optimization practices oriented towards production control to the benefit of user well-being. This transition towards flexible collaboration will bring new challenges and opportunities to ensure increased production and worker well-being. Adaptive and reconfigurable systems with real-time data processing capabilities will be needed to address ergonomic issues while ensuring productivity in human-machine collaboration (Lu et al., 2021). Research on the intersection of Industry 4.0 and human factors has grown steadily, leading to numerous experiments exploring new technologies in highly digitized work systems.

The Industry 4.0 paradigm shift represented by the innovations made in the industrial sector and the effects on social and shared wellbeing. It configures the new scenario for the near future characterized by Human-

technology oriented models and design approaches. It is therefore essential to imagine that the new generation of digital and interactive tools will have to represent the theoretical and practical changes of this mutation, where technology supports and adapts to the user, reconfiguring his skills.

In such a scenario, the concept of Operator 4.0 is born, describing a futuristic vision of intelligent and skilled workers doing the job, aided by machines and digital technological tools. Such an Operator can fully utilize digital capabilities and capitalize on emerging opportunities in Industry 4.0 enabled factories (Kadir & Broberg, 2021).

Enabling technologies for Operator 4.0

The new scenario of Industry 5.0 addresses the impact of technologies on users-operators and the connections between design and future industrial systems. As mentioned, Industry 5.0 implements the Industry 4.0 paradigm by placing research and innovation as pivotal factors to generate a network of sustainable industries, based on founding elements such as the centrality of the user, sustainability and resilience.

In this context the Operator 4.0 is born, as Taylor et al. (2020) argue, that will move from “operator” to “decision-maker”, working with digitized and automated production systems and using creativity to solve unexpected and unforeseen challenges. Following these futuristic visions, Romero et al. (2018) highlight future operators will need to be able to manage different work situations and complex interactions. Therefore, they need to receive the right information and organized knowledge to fit their cognitive processes. Similarly, Peruzzini et al. (2019) consider the needs of Operator 4.0 as fundamental by adopting the human-centered approach for integrating human factors into work systems (Kadir & Broberg, 2021). The Operator 4.0 plays a key role in the factory of the future where technologies implement its capabilities and improve the tasks performed (Fantini et al., 2018). Understood as a decision-maker and problem-shooter, the intervention

of the Operator 4.0 is developed through synergy with artificial systems along all steps of the production process, from task understanding, to decision-making, to production performance (Emmanouilidis, 2019). Traditional automation systems are unable to withstand the requirements of flexibility and adaptability needed by the factories of the future. So, efforts are being made to overcome the limitations of technologies from the perspective of perception, learning and planning. Through advanced communication and adaptive control technologies, it will be possible to support human-computer interaction systems and software for connecting physical-digital realities to enhance human performance. The evolution of Industry 4.0 and the development of 4.0 technologies in the areas of Internet of Things (IoT), Artificial Intelligence (AI) and Robotics have led to the creation of Cyber Physical Systems (CPS) managed by adaptive control systems and increasingly advanced IoT systems. The new frontier is CPS that is designed to implement human-machine interactions and physical-virtual connection tools to build increasingly sustainable and human-centric plants. The Operator 4.0 can implement its capabilities becoming more and more “intelligent” with the help of enabling technologies such as Collaborative Robotics, Big Data Analytics and Augmented Reality (AR).

Collaborative Robotics will be characterized by cobots capable of performing different types of tasks and actions in direct collaboration with the intelligent operator thanks to the presence of interactive, intuitive and easily programmable technologies. This will ensure significant benefits to the industrial world such as space optimization, cost reduction, increased productivity and psychophysical well-being of the operator. In the physical human-robot interaction, factors related to the perception of the environment and the “prediction” of the human operator are requirements that the collaborative robot must acquire in order to collaborate safely with the user.

The project “Mental Health promotion of cobot Workers in Industry 4.0” (MindBot)

aims to improve the psychophysical conditions of the user-worker during the performance of work activities, adopting collaborative robots in production lines. The purpose is to create collaborative environments and workstations able to enhance the social and empathic aspects in the new industrial context.

Another enabling technology of the new industrial scenario 5.0 is Augmented Reality, which – as the Robotics – aims to improve workspaces and make them “smart” in synergy with the figure of the new operator and to transfer information from digital devices to the user in an adaptive and interactive way.

In addition, Augmented Reality offers the opportunity to connect the human-machine interface to IoT applications and production resources. This allows that the user-operator receives instant alerts on processes and smart production machines to optimize decision-making processes (Gorecky et al., 2014).

An application example of AR technology for plant maintenance is the Utility Hera system that allows the decrease of unplanned downtime, reducing the management and maintenance costs that are considerably heavy and therefore considered as unfulfilled production. Unplanned system downtime can be caused by different factors such as: hardware failures, unexpected absence of the production operator or inaccurate fault diagnostics. In fact, by focusing on such digitalization, companies will be able to increase the efficiency and competitiveness of their plants, improving manufacturing processes.

In the new 5.0 scenario, Big Data Analytics will govern an enormous amount of information moving from physical space to cyberspace. In cyberspace, Big Data is analyzed by Artificial Intelligence and the results of the analysis are returned to users in physical space (Pu et al., 2020). Big Data collection and management solutions in a 5.0 perspective will allow obtaining useful information for the definition of Key Performance Indicators (KPIs) parameters

for the analysis and evaluation of costs, productivity and status of system outputs.

The described technologies will facilitate the work of production operators by offering the possibility to better understand the performance of plants and industrial processes, as well as to effectively monitor KPIs over long periods of time and activities and to receive immediate feedback from predictive analysis. This allows the production operator to detect problems to prevent system failures and to investigate causes directly from the workstations to optimize performance and make continuous and immediate changes (Zanella et al., 2017).

Thanks also to IoT and connected systems, the possibility of benefiting from large amounts of available data will allow greater learning in a short time and will ensure increasingly innovative and applicable solutions in the factory of the future (Aquilani, 2020).

In fact, together with AI and IoT, Big Data Analytics represent the enabling technologies that will lead the transition from Industry 4.0 to Society 5.0 and provide innovative solutions to improve the psychophysical conditions of users (Sharp, 2020).

Future scenarios for the Human-Centric factory 5.0

The industrial landscape is evolving towards the human-centric vision introduced by the Industry 4.0 paradigm, in the direction of Industry 5.0, adopting technological solutions and systems designed for Operator 4.0, defining future scenarios in factories (Longo et al., 2020).

Work modalities 5.0 imply the acquisition and the introduction of new skills that are able to elaborate and to define innovative solutions to interact with the surrounding environment.

Bianchi (2018) with the concept of “augmented intelligence”, between artificial intelligence and human intelligence,

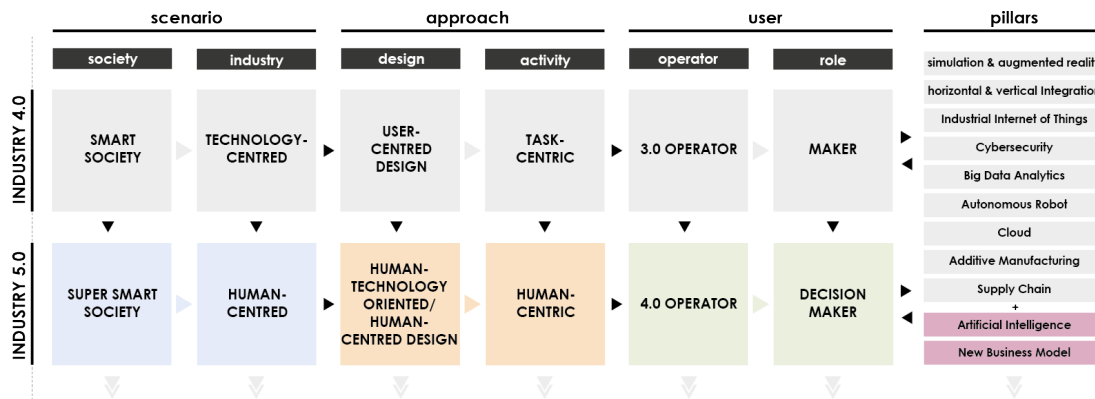


Figura 8. Graphic schematization of the three macro-areas involved in the transition from Industry 4.0 to Industry 5.0 that are classified into: transformation of the social and industrial scenario, new paradigm of anthropocentric design of the factory of the future and new role of the Operator 4.0.

highlights the increase in the degree of interactivity between human and machine, in the perspective of multiplicative perception and not replacement of human capabilities (Bianchi, 2018).

Starting from the analysis of the production scenario, the three macro-areas most involved in this new “revolution” have been identified: (I) the transformation of the social and industrial scenario, (II) the new paradigm for the anthropocentric design of the factory of the future and (III) the new role of the production operator (see Figure 1).

Starting from the configuration of the Super-Smart Society – and therefore from the birth of a hyper-connected and super-intelligent society – industrial spaces will also evolve where, through the human-centric design approach supported by enabling technologies, the figure of the Operator 4.0 will be consolidated as a user connected to the surrounding environment. The identified tools analyze the main ergonomic factors considering the operator at the center of production systems.

Figure 1 describes the main transformations from Industry 4.0 to Industry 5.0. In particular, the reference scenario from society to industry was analyzed. The new approach to the design and definition of user activities was highlighted, and finally, the role of the new Industry 4.0 operator in the industrial sector.

Therefore, the diagram shows a summary of the carried-out research activity, highlighting

the agents involved and the human-centric work activities of the future. In particular, the new factors of Industry 5.0 are outlined as added value of industry and society. In this scenario, the operators will have the management of processes and the technologies will become tools to serve the user-operator. The human-centric perspective illustrates the evolution of the figure of the Operator 4.0 defined as a hybrid agent born from the symbiotic relationship between human and machine, an intelligent and experienced operator who performs tasks (Romero et al., 2016) outlined according to specific physical-perceptual characteristics, increasing their capabilities and skills. This new human-centric model provides the evolution of aspects to be considered in the design of future factories.

Industry 5.0 develops with the growing awareness of the value of the human-machine symbiosis in industry (Longo et al., 2020) and from this understanding it will be possible to define the anthropocentric factory of the future as a “collaborative” industry. In fact, from the synthesis of Maddikunta et al., (2021) of the different definitions of Industry 5.0, considered as a phenomenon still in the process of change and definition, it is possible to highlight how the human at the center of the process is the constant factor for the configuration of the intelligent, flexible and hyperconnected model 5.0.

Conclusions

The aim of this study has been to investigate the evolution of the manufacturing system by highlighting the transition from the 4.0 paradigm to the new Industry 5.0. This represents the technological, operational and cooperative vision and places research and innovation at the service of the transition to sustainable, human-centered and resilient industry. Through the application cases analyzed, the development of new tools and the identification of new needs, the study outlines the characteristics needed for user-centered factories of the future.

The relationship between users and technologies is constantly evolving and it sees the emergence of the centrality of human who “uses” technologies on the basis of emerging needs in the industrial, social and environmental landscape.

The implementations resulting from the transition from the paradigm 4.0 to the human-centric 5.0 approach may define the future scenarios of manufacturing where the human-machine symbiosis will improve the efficiency of production.

This study also outlines the new figure of the Operator 4.0 through developments and changes in the workforce and the description of future scenarios to be addressed in manufacturing systems with particular attention to the symbiotic relationships between new robotic systems and users. Therefore, the paper illustrates the factors present in the current context in which the radical diffusion of new technologies – in particular the proliferation of robotic systems and artificial intelligence – is only in its initial phase and it suggests directions for future research in the field of human-robot interaction. This research also shows how the scientific community is particularly attentive to the human-centric evolution in the manufacturing processes 5.0.

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Symbiotic design and natural systems.

Biotechnical methodologies and Biomorphic methodologies

Introduction

How are operational knowledge extracted from biological systems and applied rigorously in project practice? Can we speak of biological methodologies, that is, of projectual methodologies of nature? And can these methods be applied in technical methodologies? Is there a technological evolutionism, just as there is a biological evolutionism (Figure 1)?

Nature has always been, in multiple ways, a source of inspiration for man. However, according to the author, there are two fundamental approaches to these uses that should be distinguished here. They are, on the one hand, a more structural and functional approach, such as Bionics and Structural Morphology, for which the name Biotechnical Methodologies is proposed and, on the other hand, a more formal approach, as are cases Streamlining and Biodesign, for which the name Biomorphic Methodologies is proposed.

These two methodologies are fundamental in the definition of "Symbiotic Design", which aims to identify the symbiotic processes applied by biological systems and to propose them as important elements in the integrated design of technological systems. In this view, the relationship between human beings and objects is proposed as a symbiotic system, in which Design assumes itself as a hinge element. This Cosimbiosis, allowing intimate cooperation, reduces the distance between biological systems and technological systems and provides a new project unit for the 21st century.

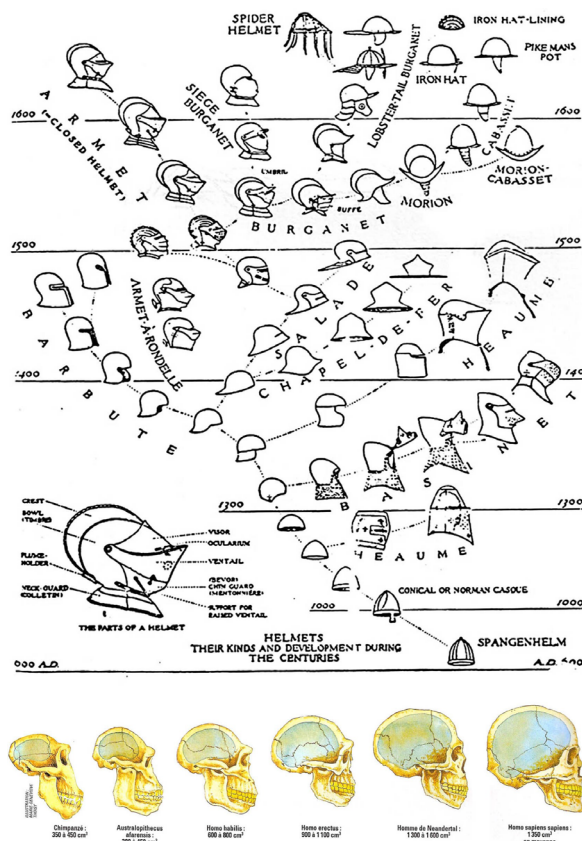


Figure 1. Above: Evolution of the helmet by Bashford Dean (1915). Below: Comparative evolution of brain volume from Chimpanzee to Modern Man.

1 - Biotechnical and Biomimetic Methodologies

Indeed, it is a given that nature and the systems used by it have been a reference for human beings throughout its history. Initially, this attitude was essentially mimetic, that is, what is commonly called Biomimicry and Biomorphism - imitation or formal inspiration of nature - and which, more recently, gave rise to proposals applied to design such as Art Nouveau, Streamlining or Biodesign. For these latter methodologies, as mentioned, the author proposes the designation of Biomorphic Methodologies - in the sense of grouping all methodological proposals that propose to analyze natural systems, living or non-living, which in a direct or indirect way, contribute to the aesthetic and formal evolution of objects and systems of man-made objects.

But also, progressively and above all following the technological evolution,

another form of inspiration appeared in nature, no longer at the level of simply the forms, but at the level of a deeper understanding of natural systems, that is, at the structural and functional level. These methodologies base their projectual praxis in Technical Biology, analysis of technical systems developed by natural systems. These proposals were based on the concept of biotechnology proposed in the 1920s by authors (Raoul Francé et al. 1920, Friedrich Kiesler 1939 and Patrick Gueddes 1915) who argued that, if nature had experienced structural, mechanical, chemical and electrical solutions over thousands of years - an "engineering of nature" -, it could, after carefully studied, be adapted and used in the design of technological systems.

In this sense, and as we will see, the first systematic demonstration of the application of Biotechnical Methodologies, according to the author, was developed by Leonardo da Vinci whose methodological process is analyzed in the chapter "From Technical Methodologies to Biotechnics", in proposals ranging from the study and dissection of animals until the study of complex phenomena of hydrodynamics and aerodynamics. Many other proposals for using these methodologies have since been developed. However, it was not until the end of the 19th century and the beginning of the 20th century that they acquired a greater systematization, with a perfectly defined and structured theoretical body, especially by Raoul Francé et al. 1920, Friedrich Kiesler 1939 and Patrick Gueddes 1915.

More recently, for project studies in this area, new disciplines have been developed and applied, such as Structural Morphology, in the faculties of architecture and engineering, and like Bionics, in the faculties of Design. For this structuralist and functionalist vision, also with several methodological proposals, such as Organic Functionalism, Biotechnics or Bionics, the author proposes to use the term Biotechnical Methodologies - in the sense of grouping all methodological proposals that in a more rigorous and scientific way, they propose to analyze the

natural technical systems, living or non-living, transporting them to the projectual culture in the perspective of producing technical or technological systems of greater or lesser complexity.

1.1 - Biotechnical Methodologies: Organic Functionalism and Bionics

The idea that the beauty of an object depends on its usefulness and efficiency is responsible for initiating a new philosophical view on material culture. Among the first functionalists, there is the German architect and urban planner Friedrich Weinbrenner (1766-1826), who writes in his work *Architektonisches Lehrbuch*, published between 1810 and 1819: "Beauty is in the total agreement between form and function". Made up of a group of three books, this work is published in Germany and especially aimed at students of Art and Architecture - "Geometrische Zeichnungslehre" from 1810, "Perspektivische Zeichnungslehre" from 1817 and "Über die höhere Baukunst" from 1819. The contents of *Architektonisches Lehrbuch* would later be complemented by two additional essays: "Über architektonische Verzierungen" from 1820 and "Über die Säulenordnungen, den Gebrauch der Säulen, die Eintheilung, Anordnung und Ausführung der Gebäude" from 1825. One of the aspects that stands out in these writings is the fact that they examine the problems of the relationship between "form and function" in architecture based on the examples of objects in current use. It is also likely that the statement by F. Weinbrenner, previously quoted, inspired the maxim "Form follows function", passed on to too many generations of designers and architects, and that this, in turn, was inspired by the work of JB Lamarck.

Friedrich Weinbrenner, Professor and architect, was born in Lehrsheim in 1766. He was "construction director" of the Grand Duchy of Baden, between 1801-1826, the main architect and urban planner in the city of Karlsruhe, and the first German architect of the 19th century to be internationally recognized. His planning for the city of

Karlsruhe - including the design of buildings, such as palaces, churches, synagogues, government buildings, city gates, shops, fountains, theaters, arms depots, cemeteries and farms - is a remarkable achievement. Its disciplinary intersection in fields as diverse as mythology, aesthetics, the history of culture and society, the history of art, geometric design and perspective, structures and materials, architectural composition, management of construction and building costs and above all, the domain of scientific theories of the time are based on the new rationalist models that were extremely influenced by the scientific movement of the 19th century.

The example of this is confirmed when F. Weinbrenner assumes the direction of Baugnade or "construction direction" of the Grand Duchy, in order to bring about social improvements through the reform of aesthetic paradigms. He announces that whoever builds according to municipal parameters, considering factors such as location, height, number of facilities, among other things, will receive a fixed economic fee. In 1815, he presented the final version of the standard construction document, in which three type houses were designed according to their location and economic class of destination. Also, with regard to the issue of urban planning, namely due to the consideration of the safety factor, F. Weinbrenner imposes specific construction rules: the buildings should have at most a height equivalent to the width of the streets; the doors should open into the houses and not out; the woods used in the interior should be at least about ninety centimeters away from any flame producer. This German architect is one of the precursors of functionalism. His ideas about beauty accentuate her agreement with the function. As the author refers, on page 6 of the third volume of *Lehrbuch*, "Über die höhere Baukunst", the author refers to beauty as *übereinstimmung der form mit dem zweck*, that is, in the total agreement between form and function, giving examples of functional objects of everyday life. But his concept of beauty is not limited to the simple satisfaction of

purposes, since it also includes adequacy and usefulness, transforming Friedrich Wienbrenner into one of the first great references of functionalism.

Another renowned functionalist author was Horatio Greenough (1805-1852), an American sculptor who lived in Italy between 1829 and 1851, the date on which he returned to the U.S., where he would pass away the following year. Considered, along with Friedrich Wienbrenner, one of the first functionalists, he published his ideas about the evolution of the arts, architecture and design in the work entitled *The Travels, Observations, and Experience of a Yankee Stonecutter*. His theories about functionalism were adopted at the end of the century. 19th and early 20th centuries by architects and designers, such as Louis Sullivan and Ludwig Mies van der Rohe. The comparison made by H. Greenough between the evolution of design and biological evolution was a precursor and would influence numerous later authors.

His observations about the functioning and suitability of natural systems, with their respective transposition to artificial systems are notable: "(...) observe the skeletons and skins of animals, through the variations that go from the beast to the bird, from the fish to the insect, are we not impressed by its variety and beauty? There is no arbitrary law of proportion and no rigid model of form". Defending that: "The law of adaptation is the fundamental law of nature in all structures", years before the publication of the *Origin of Species*, he criticized the domain of arbitrary rules of taste, installed in everyday objects. As he said: "Many works are more beautiful without ornament". And he adds: "When I

define Beauty as the promise of Function; Action as the presence of the Function; As a function record, I arbitrarily separate what is essentially one".

Defender of the function, he found in shipbuilding the exemplification of his theoretical proposals. "Watch a boat in the sea! Notice the majestic shape of its hull as it advances through the waters, observe the graceful curvature of its body, the gentle transition from the curved to the flat, the firmness of its keel, the launch of its bowsprit, the symmetry and rich outline of its masts and risers, and those big wind muscles, the sails!". The analysis of the characteristics of shipbuilding will then be proposed as an example to be followed in civil construction Figure 2: "We could transfer to civil architecture the responsibilities that weigh in shipbuilding and we would have long buildings superior to the Parthenon for the purposes for which they were intended (...)". Anticipating all pedagogical theories of design, he says: "I wish to see normal schools of structure and ornament working, organized in a simple but effective way, and constantly busy in designing for manufacturers, and for all mechanics who need guidance aesthetics in your operations".

But H. Greenough goes even further in defending a notion of progress associated with the role: "If you go through the various stages of development of the boat, from the canoe dug in the trunk of the tree and the old galley, to the latest types of corvettes, we will note that any progress in performance has been a progress in composition, beauty or grandeur, in accordance with the function of the vessel".

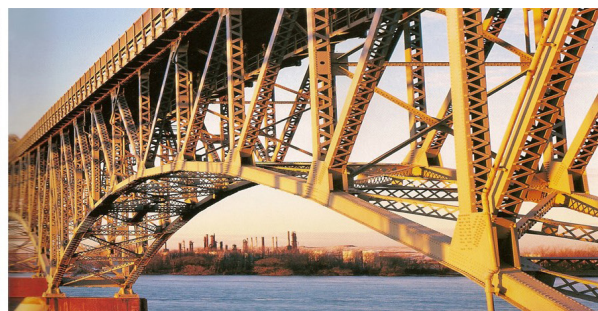
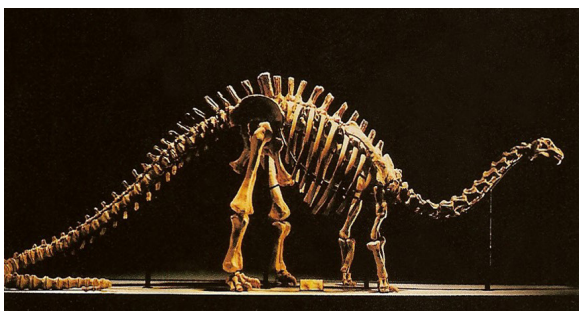
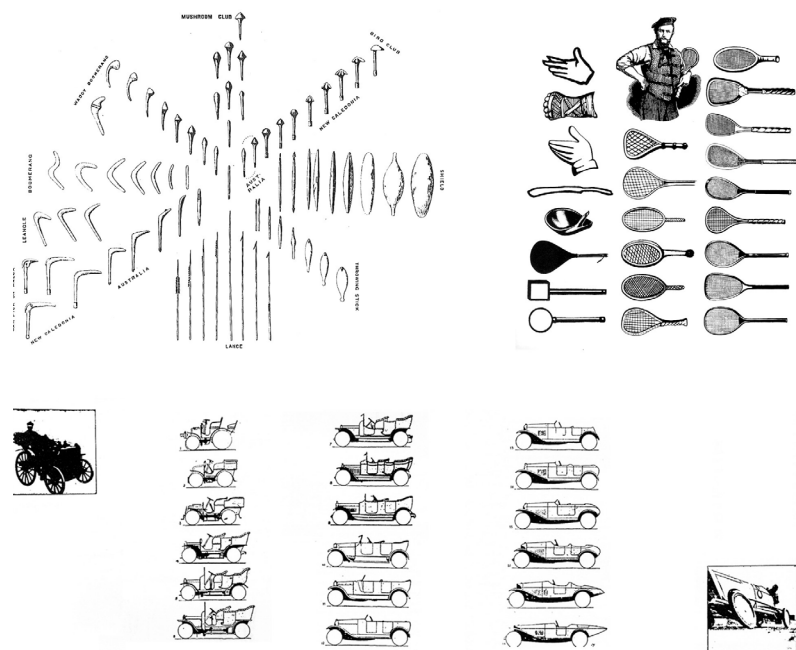


Figure 2. Brontosaurus skeleton and bridge structure on South Grand Island, New York. Analogy established by Alan Powers, in *Nature in Design* (1999).

But change is not enough, as Alfred North Whitehead says: “There can be meaningless change and no progress”. The term progress would therefore be more appropriate, and James Ferguson, an English writer and scholar, in his book *An Inquiry into the True Principles of Beauty in Art*, published in 1849, dedicated a chapter to the theme with the name “Progress of Art”, in which, in this thematic perspective, refers to the evolution of ships as follows: “We have a constant progress (of ships) over

As P. Steadman points out, more than a great leap resulting from a brilliant inventor, the great progress was due, for millions of years, mainly to the work of anonymous artisans and mechanics who with their combined efforts were responsible for small and sequenced progress. These notions of progress and evolution of objects appear perfectly visible in the illustrations by A-H. Pitt-Rivers on the evolution of the boomerang, of 1906 - whose precursor work was previously referred to in the article "Orthogénésis of the Tools" - in Bashford Dean's on the evolution of the helmet, of 1915 (cf Figure 1) and, more



recently, in Le Corbusier's 1921 evolution of the automobile. Figure 3

The study of social systems also presupposes evolutionary theories, as we have already seen. As R. C. Lewontin and R. Lewis refer: "The evolutionary theories of social systems, namely Marxism and some of its variants, are explicitly progressive and perfectionist". And then they add: "And the stories of religion, philosophy, science, fine arts, industrial techniques, show the existence of a succession of states." That is, in modern theories of evolution, C. Darwin was a culmination and not its origin. C. Darwin himself, in fact, in the third edition of *Origin of Species* of 1861, makes a historical outline of the writings that preceded his, on organic evolution.

Basically, the evolutionary analogies of H. Greenough or J. Ferguson, among others, predate the publication of the *Origin of Species*, thus demonstrating the existence of the genesis of an evolutionary theory of technology and a notion of progress related to systems or technological organisms, even though, in this case, the reference to "evolution", as defended by P. Steadman, refers more strictly to the sense of "progress" or "development". As H. Spencer - the greatest defender of evolutionary progress in the 19th century - says in *Progress: Its Law and Cause*, 1857: "From the first traces of cosmic changes to the last results of

civilization, we find that the transformation of the homogeneous into heterogeneous is what progress essentially consists".

The functionalist vision of H. Greenough marked proto-modernism by proposing "beauty as a function commitment." In the book *Form and Function - Remarks on Art* by Horatio Greenough, the editor says on the back cover: "It was Greenough, not Walt Whitman, who first protested the lack of meaning in ornamentation. It was Greenough, not John Ruskin, who first expressed the idea that a people's buildings and art express their morality. It was Greenough, not Le Corbusier, who first said that buildings primarily for use "could be called machines". It was Greenough, not Louis Sullivan, who first spelled out the principle that, in architecture, form must follow function." But as we noted earlier, it was not H. Greenough but F. Weinbrenner who first said that the form must follow the function. This important German author owes the maxim of functionalism. But perhaps even more important and less publicized in the work of H. Greenough, are his proposals for the analysis of natural structures intended for later application in artificial systems, anticipating future biotechnological methodologies. Later, this will be a great step in the methodological and scientific consolidation of the referred processes of analysis of the natural structures.

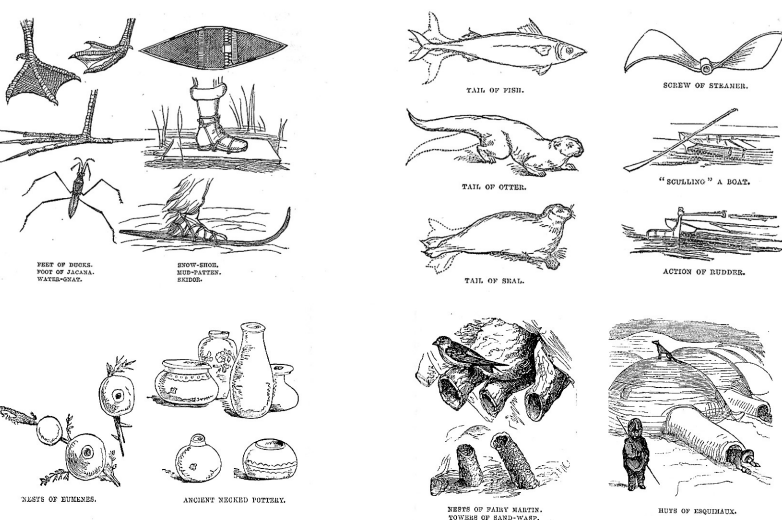


Figure 4. Comparative studies between natural and technical systems illustrated by Reverend Wood.

The *Origin of Species* would be crucial for the understanding of biological evolutionism and for the consequent creation of a support base for the development of technological evolutionism, this one previously explored based on Lamarckian theories, closer to the adequacy to technological systems. However, it is very important to keep in mind that this work by C. Darwin was published seven years after the death of H. Greenough, which is to say, seven years after the edition of his book *The Travels, Observations, and Experience of a Yankee Stonecutter*. H. Greenough's work remains in history as a reference of functionalism, extremely important in the evolution of project culture and biotechnological methodologies.

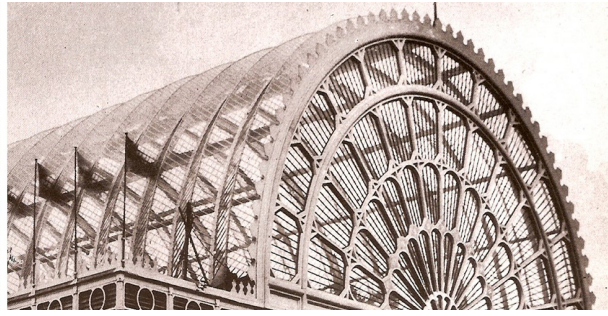
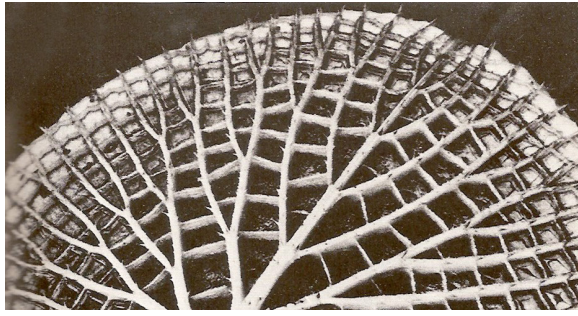


Figure 5. Lower structure of the water lily *Vitoria Regia* and gallery structure of the Palácio de Cristal (1851), by Joseph Paxton.

Also a forerunner in the analogies established between nature and art is the work of Reverend John George Wood, published in Boston in 1875, with the suggestive title *Nature's Teaching's: Human Invention Anticipated by Nature* Figure 4, where the author, using different areas of human knowledge ordered by chapters such as "nautical", "hunting and war", "architecture", "utensils", "optics", "utilitarian arts" and "acoustics", seeks to demonstrate that prototypes that can help in concretize human productions. This manual is probably the first comprehensive survey of comparisons between biological and technical systems, with about 750 illustrations that help to understand the analogies advocated by J. Wood.

One of the most famous examples he mentions in architecture is that of the Crystal Palace designed by Joseph Paxton and inaugurated for the Great Exhibition of 1851. Inspired by the leaf ribs of the giant water lily *Victoria Regia*, it is a good example of Structural Morphology. Figure 5 But hundreds of other examples appear in his work, establishing analogies between examples taken from Biology and human production.

Another reference work and perhaps the first to use the term "Biotechnics" is the book by the German Raoul Francé, *Die Planze als Erfinder* (Plants as Inventors), published in Stuttgart in 1920. According to him, all forms of nature are a product of natural selection and a consequence of functions developed by organisms in their adaptation, that is, their forms are the solution to solve problems that biological systems encounter. In this sense, R. Francé

proposes that anyone looking for a technical solution, should study "biotechnology", and thus seek a solution to the same problem in biology and imitate it. Lazlo Moholy-Nagy, artist and emblematic professor at Bauhaus, defended and disseminated R. Francé's ideas at the famous school, citing him even in his book *The New Vision*, referring to R. Francé as follows: is an intense study of the analogy between biology and technology, and draws on its research method and its biotechnical results ". But L. Moholy-Nagy allowed an opening in the mimetic process in that, according to his view, the important

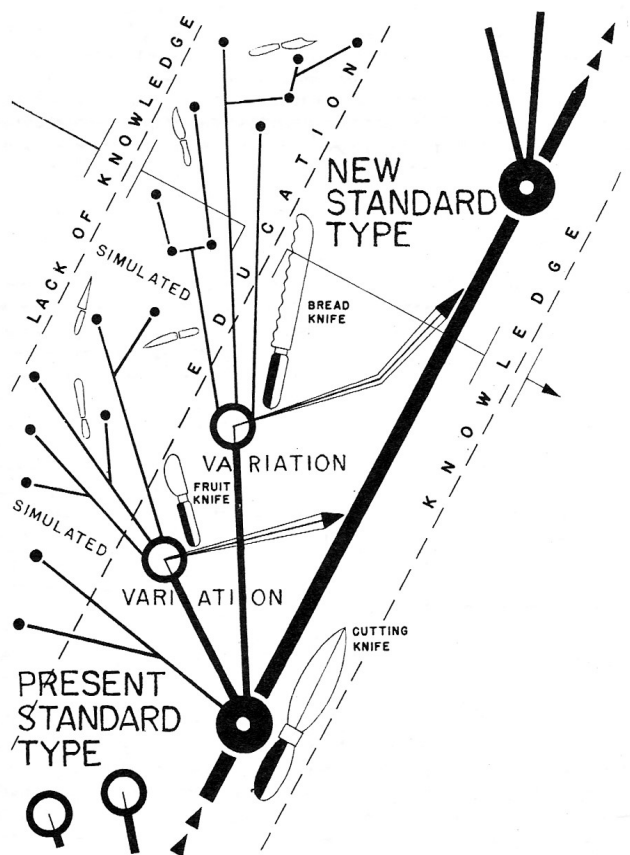


Figure 6. Diagram by F. J. Kiesler that shows the evolutionary process of the "standard type" of the knife (1939).

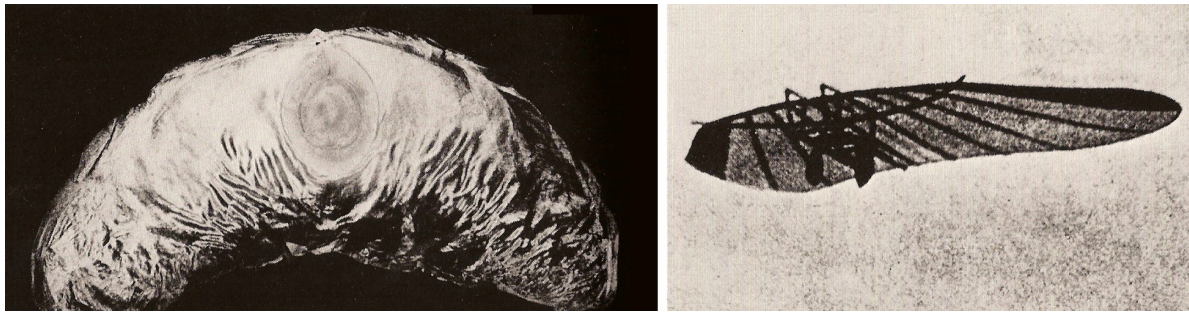


Figure 7. Glider seed of the *Zanonía macrocarpa* and *Zanonía glider* (1904) of the aviation pioneers Etrich and Wels.

thing was to follow the general principles of the methods of nature, that is, for him it was possible to conceive works “that functioned organically”.

Another important reference in this area is the article On Correalism and Biotechnique by the architect Friedrich Kiesler, published in the *Architectural Record* of 1939. According to the author, correalism means the study of the relations between man and his natural and technological environment. F. Kiesler argues that “instruments and architecture are created to serve as mediators between man and the natural environment and therefore form a second and interposed, “technological environment”. For this author, all utensils go through an evolution process with several states that correspond to “variations” from the “standard-type”, as shown in the knife’s evolution scheme. Figure 6

But, unlike what happened with the previous authors, for F. Kiesler, biotechnology is not a simple copy of natural prototypes, but a method capable of polarizing natural forces in the direction of man’s intentions. In this sense, he distinguishes between biotechnology and biotechnique, attributing the latter to Patrick Gueddes and defining it as “a method of building nature ... and not man”. Also, of anticipatory reference is, in the book *Cities in Evolution* by P. Gueddes, biologist and pioneer of urbanism, published in 1915, the introduction of the terms “biotechnology” and probably the term “biotechnical”. In the same work, he also proposed the terms “paleotechnical” and “neotechnical”, referring to the first rudimentary and disastrous phase of the Industrial Revolution and the second to

an emerging industrial order that tended towards prosperity, beauty and harmony with the environment Natural.

Thus, studies in the field of biotechnology began to be formulated, which would be widely disseminated and developed in the post-war period, with the introduction of notions such as Technical Biology and Bionics. If, in the first, the objective is the study of formal and structural systems produced in biological systems, in the second, in addition to the analysis of natural systems, the respective synthesis is produced that allows the future application of knowledge in technical and technological systems produced by human beings. This is not a purely theoretical process, but a rigorous and scientific method of transforming organic structural and functional systems into technological systems, thus allowing their subsequent application in the project culture Figure 7. The study and investigation of these biological and biochemical systems allows the construction of prototypes later used in the design of synthetic systems. Although naturally more developed, these post-war proposals are, however, nothing more than the “biotechnical” proposals presented, in the 1920s and 1930s, by P. Gueddes, R. Francé and F. Kiesler and which were defended as a methodology by L. Moholy-Nagy.

The proposal for the name Bionics is attributed to the major of the US Air Force, Jack E. Steele in 1958, and according to J. Steele, it means “systems science whose function is based on living systems, or which have characteristics of living systems, or that resemble them”, having been, however, later defined with more precision

by David Offner as: “The study of living systems or assimilable by the living, tending to discover new principles, techniques and processes of application to technology. Bionics analyzes biological systems, their principles and fundamental characteristics from a qualitative point of view, in order to draw inspiration for the development of new orientations in the design of technical systems that have similar characteristics”. Although Bionics was considered by J. Steele as a new science and was officially presented in May 1960 at the Annual Aeronautical Electronics Conference, that name is given by J. Steele with no knowledge that this new science already existed under the name of Biotechnics (in English Biotechnics) according to a proposal by P. Gueddes, from 1915, or by R. Francé, from 1920.

One of the best known systems for the application of methodologies and processes of biotechnological methodologies in a widespread product is the fixation system invented in 1941 by the Swiss engineer Georges de Mestral, which is usually known by the name of Velcro. The name, according to its inventor, derives from the combination of the French words “velours”, which means velvet and “crochet” which means hook.

This fixation system is based on a process developed by some plants, of which Burdock seeds stand out, which, when coated with small tentacles with hooks at the end, allow their attachment to the animals' fur, thus allowing their transport to other locations and, consequently, the spread of the plant. Sometimes these seeds, in their natural fixation process, also adhere to clothing. This was what happened to G. de Mestral when, while walking in the mountains of the Swiss Alps, he observed that these seeds were fixed on his clothes and on the coat of his dog. Developed by G. de Mestral, the quick fixing system works by producing two nylon tapes, one of which is coated, on one side, by tiny hooks that in contact with the other tape, covered by tiny rings, allows the anchoring the hooks in an extremely resistant way and with a number of almost infinite possibilities of



Figure 8. Left: Suppository packaging based on the pea pod (1960s), by Victor Papanek. Right: Burdock, plant that served as inspiration for the development of Velcro, expansion of Velcro structure, Velcro system.

use Figure 8. Patented in 1951 by its inventor, today, the Velcro brand has more than 300 registrations in about 160 countries.

One author who systematically defended the use of Bionics in design processes was Victor Papanek (1935-1998). Born in Austria, he graduated in architecture and industrial design in the USA, subsequently becoming interested in subjects such as Ethnology and Biology and, thus, creating the basis for the development of what would come to be called “Design for Needs” (Design for Need); representing a reaction to the consumer society, the author defended a design designed for real human needs. Already previously, another author, Richard Buckminster Fuller, had made proposals in this regard, which culminated in his research project World Resources Inventory, developed at Southern Illinois University, which proposed a review of the distribution of global resources so that they could be used in a more efficiently. Also, Richard Neutra, in 1954, published his book *Survival through Design* that defends a worldwide strategy for non-commercial design. But it would be V. Papanek with the publication of his book *Design for the Real World*, in 1971, who would assert himself as responsible for the great dissemination of the notion Design for Need, as well as the concept of Bionics. Indeed, this book has been translated into 23 languages, making it the most widely read design work in the world. With the subtitle “Human Ecology and Social Change”, in this book V. Papanek’s views on the ethical, social and environmental

issues of design are approached in an unprecedented systematic way. In that same work, the author also dedicates a chapter to Bionics, entitled “The Tree of Knowledge: Biological Prototypes in Design” in which it provides a simple definition of the term: “use of biological prototypes for the design of man-made systems. “

Other more contemporary proposals, mainly developed after the energy crises of 1971, 1973 and 1974, seek to create positive interfaces between technical systems and environmental systems. Among the main ones are Green Design (Ecological Design), Ecodesign (Ecological Design), Design for Environment (Environmental Design) and Sustainable Product Design. Alastair Fuad-Luke's book, the eco-design handbook is, in this sense, a very complete manual of products in which these concerns are thoroughly analyzed. The methodologies of the proposals in question are not necessarily based on Technical Biology, as they seek, fundamentally - with more or less efficiency, and through different processes and methodologies - to make the products and the product systems compatible considering, respectively, variables such as their production, distribution, use, destruction, recycling, reuse, that is, the factors that can be readjusted in order to reduce the environmental impact of everything that human beings produce. In this sense, these methodologies usually resort to processes such as: Life Cycle Analysis, Environmental Management, Eco-audits, or Energy Flow Management. Focusing mainly on the inside of the technical system, they will be able, through the use of Biotechnical Methodologies and Design, to have access to a new vision, external to the human technical system, which may bring unexpected and innovative information flows. It will certainly be part of contemporary Biotechnical Methodologies to use, in its design process, information provided by these environmental methodologies.

Biotechnical methodologies have, in fact, been an indispensable resource in the evolution of technological systems,

acquiring an increasing importance in the current context of debate on environmental crises. The latter, in turn, have led to the priority search for approximation solutions and greater compatibility between technological systems and biological systems. However, the potential of biotechnological methodologies - applied in project areas such as Design, Architecture or Engineering - has, however, been underused; although the projectual knowledge is in a process of maturation in which Nature tends to be, increasingly, an example to follow in the century. XXI.

1.2 - Biomorphic Methodologies: Streamlining and Biodesign

Other methodologies that use natural systems as a reference are those that the author called as: biomorphic methodologies. This denomination intends to group all the methodological proposals that propose to analyze the natural systems, living or non-living that, in a direct or indirect way, contribute to the aesthetic and formal evolution of objects and systems of objects produced by man. More linked to the morphological transposition of natural elements to artefacts, these have been present in material production since its inception. As P. Steadman says: “The use of plant and animal figures in decoration is practically universal throughout the history of architecture and applied arts; in the last half of the 19th century, however, there was a special interest (...)”.

It is, in fact, at that time that some of the great works on this theme are published, coinciding with the discoveries made in Biology. In other words, project culture accompanies scientific development. Among the most important works to establish this bridge, as P. Steadman refers, is Owen Jones' Grammar of Ornament, published in 1856, defended by its author as a practical guide of documentation based on natural elements, intended for designers.

But we can affirm that the great diffuser of the application of this methodology in

industrial products, in a systematic way and with scientific foundations, was Christopher Dresser (1834-1904); considered by some historians - and defended by the author of the present work -, as the first, modern product designer. As Stuart Durant says, "He revealed himself in the machine's triumph and understood his demands more clearly than any of his rivals." In fact, in addition to being a designer, C. Dresser was also the author of theoretical studies on this subject, highlighting in this context two important works of his: *The Art of Decorative Design*, from 1862, and, later, *Principles of Decorative Design* (1873); Figure 9 in the latter, C. Dresser encourages "young decorators to study the principles on which nature works".

That last book, based on some articles that C. Dresser published on the relationship between natural forms and design, Figure 10 is followed, in 1874, by the article *Studies in Design*. Any of the works will have been influenced by the investigations produced for his doctorate in botany, defended in 1860.

C. Dresser studied design at the Government School of Design in 1847, where he proved to be the most talented student. He was invited to teach botany classes at the school in 1854. In 1860, at the age of 26, he received his doctorate from the University of Jena, Europe's most advanced scientific center in botany, located in Germany. He opens his design studio and, in 1876, asserts himself as the first western designer to visit Japan. This trip, on behalf of the British government, lasts four months and allows him to get in touch with artistic production, arts decorations and architecture of that country, the result of which will be the publication, in 1882, of the book "*Japan: Its Architecture, Art and Art Manufactures*". Four years later, C. Dresser would also publish *Modern Ornamentation*, a book that includes works produced by his design studio. The contribution of C. Dresser in design processes, illustrated in these books and in the dozens of articles published by him within the same themes, is decisive for the way he systematically applies the

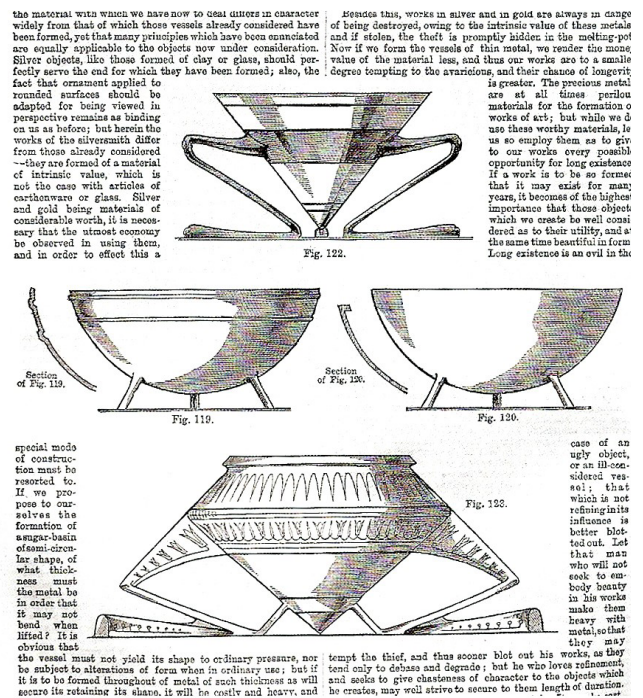


Figure 9. Page from the book *Principles of Decorative Design* (1873), by Christopher Dresser.

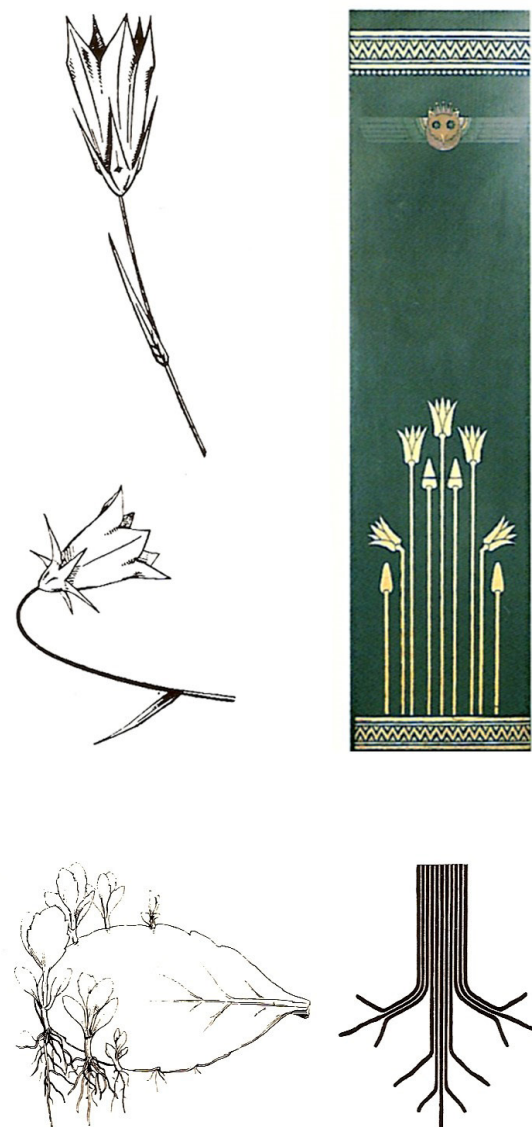


Figure 10 Drawings of analysis and synthesis of natural elements (1859-1880), by Christopher Dresser.

influences of elements taken from the world to the project. Natural. Considered as the first independent industrial designer, in a tribute dedicated to him by the English magazine *Studio*, in 1899, its importance is highlighted as follows: "possibly the most important of commercial designers, he imposed his fantasy and invention above ordinary industrial production British". Figure 11

Through his flourishing studio, C. Dresser has designed hundreds of products for more than fifty client companies not only in England, but also in France, Japan and the USA, in areas as diverse as furniture, tableware in ceramics, glass and metal, textiles or wallpaper, presenting a diversity and quality of radical designs in relation to the current Victorian style. His designs were so innovative that some of them are still in production today, highlighting, in this sense, the undertaking undertaken by the Italian company Alessi, which recently marketed some replicas of products designed by C. Dresser. In fact, his inspirations had as main reference elements taken from the observation of nature, as well as elements of Japanese art and pure geometries, in an aesthetic path in which the formal simplification and its innovative capacity



Figure 11. Ceramic products (c. 1870) by C. Dresser showing the influence of pure geometries, Japanese art and observations of nature.

has been progressively solidified.

C. Dresser believed and defended the supremacy of form over ornament. In the way he assumes the materials and the extremely refined language, C. Dresser can

be considered as one of the first modernists, which influenced him a lot. His optimistic view of the future industrialization and the importance of machine production would be references that, only in the 20th century, would be taken up again, namely in the work carried out at Bauhaus, in the metal workshop directed by L. Moholy-Nagy, of which the pieces by Marianne Brandt are a good example of the continuity of C. Dresser's work.

Still in the late 19th and early 20th centuries, Art Nouveau - whose name derives from a Parisian store, *Maison de L'Art Nouveau* -, with its formal inspiration drawn from plant elements, stands as a widely known example from the application, to the project, of ornamental and structural vegetal motifs, stylized. This application of biomorphical methodologies in Decorative Arts and Architecture had an enormous expression in the Western world, but it would be the North American Streamlining that, in the thirties, would revolutionize the application of biomorphic methodologies through the exploration of inspirations taken from nature, namely aerodynamic and hydrodynamic, whose formal application to the project required technologically very complex solutions.

This current - which includes Norman Bel Geddes (1893-1958), Raymond Loewy (1893-1986), Walter Dorwin Teague (1883-1960) and Henry Dreyfuss (1904-1972), all of them working in industrial design at the end of the 1920s - it was strongly marked by the influence of aerodynamic and hydrodynamic forms and can be considered the first application of the notions involved in both areas to highly consumed industrial products. N. Bel Geddes has a strong responsibility for the dissemination of streamlining, through his book *Horizons*, published in 1932 and with enormous success. This work served as an example for the other designers of the streamlining, of which the publications of: *Design This Day* by W. Teague, 1940 stand out; *Never Well Enough Alone* by R. Loewy, 1951; and *Designing for People* by H. Dreyfuss, 1955.



Figure 12. Products designed by Christopher Dresser: Sugar bowl for Elkington (1864); Kettle for James Dixon (1879); Terrine for Elkington (1885).

Of great influence in the streamlining of the shapes of N. Bel Geddes, were the expressionist projects of industrial buildings by the Austrian architect Erich Mendelsohn carried out between 1914 and 1918. This influence, assumed by N. Bel Geddes in the introduction to the catalog of the work of E. Mendelsohn, during the exhibition in the USA of the Contemporary Exposition of

the New York World's Fair in 1939, which was visited by twenty-five million people. As the name Futurama indicates, this exhibition presented a city of the future, interpreted according to the avant-garde visions of its author.

N. Bel Geddes also stands out, in terms of product design, the designs of the Toledo

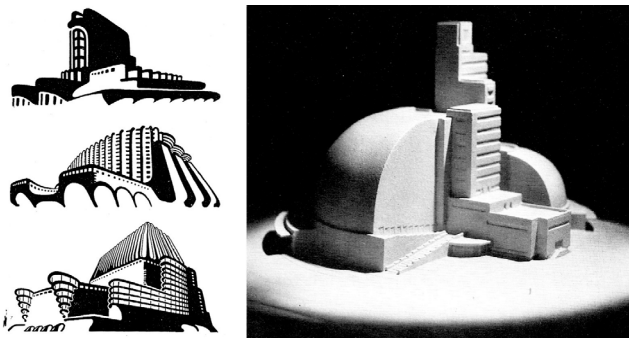


Figure 13. Left: Drawings of industrial buildings by Erich Mendelsohn (1914-18). Right: Model of Repertory Theater (1929) by Norman Bel Geddes.

Art and Industry of 1929, will be present in most of his projects. Figure 13

Early in the career of N. Bel Geddes, this influence is verified in the projects of theaters and theatrical scenarios that he develops. In 1927, the American designer decided to dedicate himself to industrial design and, in this context, in addition to developing projects for his clients, he also developed visionary aerodynamic projects such as boats, airplanes, cars and trains, houses, airports, new motorway systems and traffic models, whose ideas would come to fruition at the Futurama exhibition, integrated in the General Motors stand at

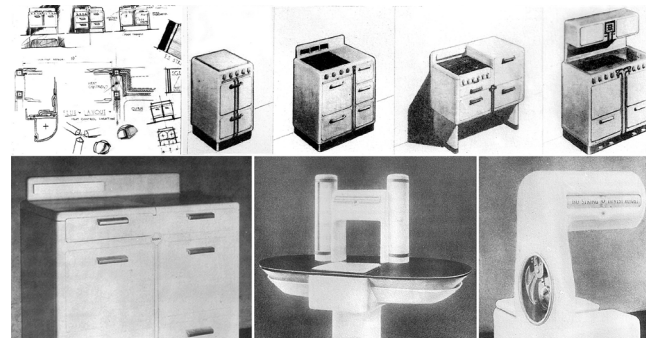


Figure 14. Above: Norman Bel Geddes sketches for Standard stoves. Below, from left to right: Standard stove (1932) and Toledo scale (1929).

Counter Scale, from 1929, and the Standard Gas Equipment Stove, from 1932. Figure 14

With regard to the transport design developed by you, refer to the projects of the Air Liner # 4 airplane, from 1929, the Locomotive No. 1 train, from 1931, and the Streamliner Ocean Liner boat, from 1932; Figure 15 extraordinary examples of the application of biomorphic languages that have had a great influence on some later proposals such as those by Luigi Colani and Biodesign.

The work of N. Bel Geddes was a pioneer in the introduction of Industrial Design in the U.S., having subsequently also proved to

be an internationally important influence. As he himself said: "As the artists of the fourteenth century are remembered for their

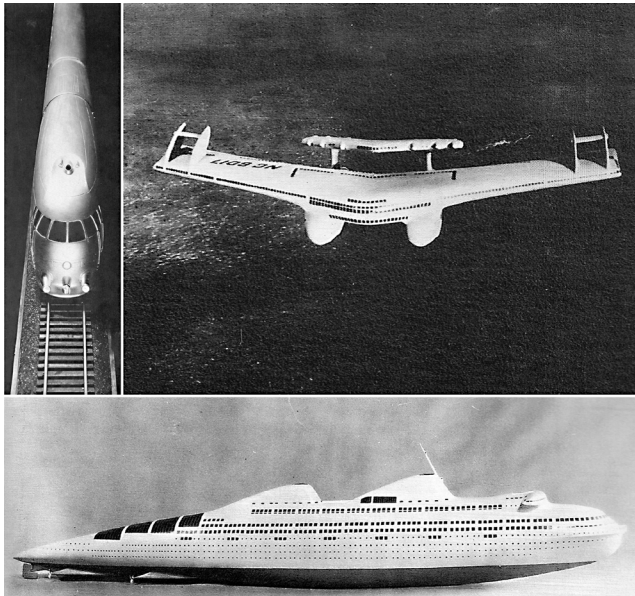


Figure 15. Transport projects by Norman Bel Geddes. Above: Locomotive N°1 (1931), Air Liner # 4 (1929). Below: Streamliner Ocean Liner (1932).

cathedrals, those of the twentieth century will be remembered for their factories and the products of those factories".

The meaning of this same comparison would be reaffirmed by R. Barthes, in 1957, in the text "The new Citroen" published in his book Mythologies: "I believe that the automobile is today the exact exact equivalent of the great Gothic cathedrals (...)". Figure 16

In the continuity of N. Bel Geddes' organic and aerodynamic language, we find, as already mentioned, Biodesign - a name attributed to the biomorphic language explored by the German designer Luigi Colani.

Born in Berlin and registered under the name of Lutz Colani (b. 1928), he studies



Figure 16. Notre Dame de Paris Cathedral (1163) and Citroen DS19 (1957).

sculpture in this city, moving, in 1948, to Paris where, at Sourbonne, he develops studies on "aerodynamics". In 1952, he moved to California to study aeronautics at Mc Donnell Douglas' New Materials division; again in the United States he would later work for NASA and Boeing (1974). Back in Europe, he presented, in the 50s and 60s, a series of aerodynamic proposals in the automotive sector, of which the projects, in 1952, of a turbine-propelled motorcycle stand out; for Simca, in 1953, the first European car with a plastic body; and in

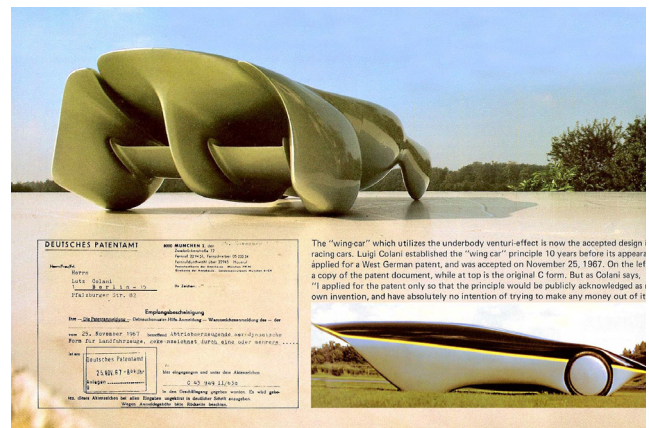


Figure 17. Projects by Luigi Colani. Top and left: original C-Form aerodynamic body and patent (1967). Bottom right: Low consumption vehicle with high aerodynamic capacity, with Cx of 0.2 (1982).

1967, the body of the C-Form car, which will be the origin of all aerodynamic bodies with a ground effect.

In the 70s and 80s, L. Colani proposes a wide variety of biomorphic language projects, developing transport in the form of birds, rays or sharks. Of these, we highlight the 1977 Megalodon passenger plane, based on the shapes of the shark, the Super-High-Speed Monorail Car train, from 1978, based on the shapes of the streak, or the Yacht boat inspired by the shapes of the whale, from 1981. Figure 18 As the author

says: “The shape of a shark is a perfection ... This animal has modified and perfected the effectiveness of its shape for millions of years, we cannot dream of a better one!”.

But L. Colani does not design only transports. His work presents an impressive variety of proposals, ranging from sportswear, lingerie, shoes, glasses, jewelery, watches, pens, weapons, lighters, glass and ceramic tableware, toilets, tap lines, televisions, furniture and even architectural proposals. In terms of transport, he designed bicycles, motorcycles, automobiles, racing vehicles, sailboats, transport boats, oil tankers, helicopters, cargo and passenger planes and even spaceships. It applies organic, hydrodynamic and aerodynamic forms (an area in which L. Colani is a specialist and precursor), sometimes exaggerated, to his mega-projects, adopting an extremely diversified path in his curvilinear language, ranging from more rigorous proposals influenced by

L. Colani, reveals on the small scales a revolutionary attention to ergonomic and anthropometric details. As he himself says: “Engineer’s design products in order to facilitate production: their products are often angular and aggressive. I strive to devise lines that reveal the mark of the human body on the object. And in the case of photography, the relationship between the device and the hand is paramount”. In the industrial product area, which he designed, the following stand out: in 1981, the ballpoint pen for Pelikan; in 1984, headsets for Sony; in 1991, binoculars for Bresser; in 1993, the “mouse” and the “joystick” for Highscreen, Figure 19 and, above all, the cameras he designed for Canon, of which the T90 stands out, one of the most popular products by L. Colani.

In fact, L. Colani started a collaboration, in 1974, with the Japanese company Canon, which will strongly influence the future industrial products of the brand. This collaboration gave rise to a series of

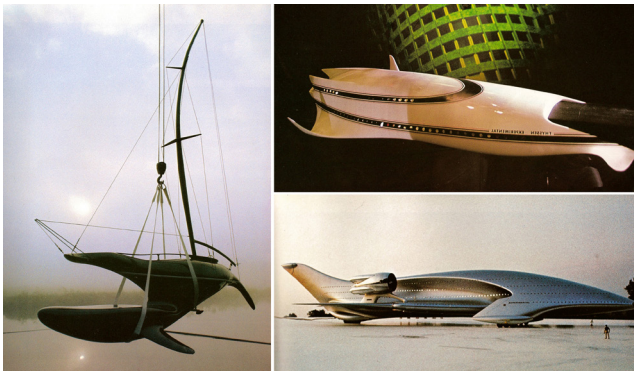


Figure 18. Projects by Luigi Colani: on the left, Yacht (1981); top, Super-High-Speed Monorail Car (1978); bottom: Megalodon plane (1977).

aerodynamics, ergonomics and product engineering, to the megalomaniac projects of transport systems that present an organic-expressionist language, sometimes baroque.



Figure 20. Camera Models (1982) designed by Luigi Colani. Above, from left to right: Model CB10 and Model Hy Pro. Below, from left to right: Model Frog and Model Homic.



Figure 19. Products designed by Luigi Colani: Ballpoint pens for Pelikan (1981); mouse for Highscreen (1993); binoculars for Bresser (1991).

experimental models of photographic devices in organic forms such as the more conventional CB 10 and Hy Pro and the Frog and Homic designed for underwater photography. Figure 20

He applied the formal principles of Biodesign to these projects, “considering that these are objects that we hold in our hands and touch our faces”. These models later gave rise to the Canon T90, the most complex of the T series, the result of L. Colani’s collaboration with the company’s design office, announcing the influences of its boldest models. Launched in 1986 in Japan, it quickly became an icon of industrial design, influencing the design of thousands of products worldwide. This experience demonstrated in practice, in a very evident way, how a designer with new conceptions sometimes considered utopian can collaborate with the project office of a large company and achieve an innovative result. The T90, with its organic forms that were clearly demarcated from the small black box style parallelepiped box, has historically revolutionized not only the Canon range but also those of the competition. Figure 21 This formal trend naturally expanded later on to most products consumer electronics, first to portable objects such as transistorized



Figure 21. Canon photo cameras, series T. Above, from left to right: T50 (1983), T70 (1985). Below: T80 (1985) and T90 (1986).

radios, walkman’s, diskman’s, etc. and subsequently to other more complex products. This helped that this type of product became more ergonomic and even more sensual.

⁹But this fact also forced the development of more perfected CAD (Computer Aid Design) systems, capable of representing and manipulating all these complex forms, allowing to create a skin that involves all the internal organs of these products. Enabling the use of more organic and ergonomic forms, there was a formal and structural approach to the human body, acting almost as extensions of it. As Raymond Guidot says about the projects developed by L. Colani for Canon: “Colani found shapes that somehow prolong those of the human body”.

Conclusion

In this perspective, biological systems present an inexhaustible diversity of solutions tried for thousands of years, ranging from morphological evolutions, the development of structural or dynamic systems, the modes of information transmission and interfaces, but it is mainly from a wide knowledge of the system in which the object is inserted, that it will be possible to project it so that its adaptation is complete. In this sense, the contribution of areas such as Biology and Chemistry, as well as that of social and economic sciences, Physics and Mathematics will be essential for the enrichment of project culture and for the creation of a future universe of fusion between natural and artificial. This proposal, which we will talk about later, passes, as is defended by the author, by the definition of symbiosis methodologies for a fusion design or Symbiotic Design that, considering biotechnical and biomorphic methodologies such as Bionics or Biodesign, goes further to the propose a new methodology of symbiosis between natural and artificial systems, with sharing of energy, communication and usage systems.

Symbiotic Design is an attempt to understand and apply the methodologies and processes of the great Symbiotic Project that nature has been developing. Applying these methodologies and processes does not guarantee “success”, because even

nature learns through experimentation, but it places us within the process, that is, with a greater probability of evolving more integrated and, therefore, with greater success. The 21st century, could be that turning point in this direction. We hope that this is the future, the construction of a “universe of symbiosis” and the preservation of the “Living Laboratory called Terra”. And on that day, we can say that we are an integral part of the Symbiotic Planet!



Figure 22. Planet Earth, about 4.5 billion years experimenting with symbiotic methodologies.

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proyecta 56

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Artículo de investigación | Research Article

Autoencargo, Intuición y Prosumer | Self-commissioning, Intuition and Prosumer

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Resumen

El autoencargo en diseño se refiere a la práctica de establecer objetivos y metas para uno mismo en lugar de tener un encargo o brief de empresa. En el autoencargo el creador tiene mayor control sobre el proceso creativo y puede enfocarse en sus propias visiones. La intuición creativa, como capacidad de confiar en la inspiración y las ideas que surgen de manera espontánea, no depende de métodos creativos tradicionales. La combinación de ambas prácticas, autoencargo e intuición creativa, puede permitir una mayor libertad para explorar ideas y enfoques originales. Por otra parte, el “prosumer”, combinación de las palabras productor y consumidor, y que se refiere a la práctica de los usuarios de convertirse en productores activos de productos, en lugar de simplemente consumir lo que les ofrecen las empresas, es un creativo que encaja adecuadamente en el autoencargo y la creación propia. En el contexto creativo, esto puede significar que el creador es tanto el productor como el consumidor de su propio trabajo, utilizando su intuición creativa y autoencargo para producir contenido original y único, que también es apreciado por otros. Estas prácticas pueden ayudar a los creadores a tener un mayor control sobre su proceso creativo, explorar ideas originales e innovadoras, y crear contenido que sea relevante y atractivo para otros usuarios.

Palabras clave: autoencargo; intuición creativa; prosumer; creatividad; diseño de producto; práctica de diseño

Abstract

Self-commissioning in design refers to the practice of setting goals and objectives for oneself rather than having a brief or brief from the company. In self-commission, the creator has more control over the creative process and can focus on his own visions. Creative intuition, as the ability to trust inspiration and ideas that arise spontaneously, is not dependent on traditional creative methods. The combination of both, self-commissioning and creative intuition, can allow greater freedom to explore original ideas and approaches. On the other hand, the “prosumer”, a combination of the words producer and consumer, and which refers to the practice of users becoming active producers of products, instead of simply consuming

what companies offer them, is a creativity that fits appropriately into self-commissioning and own creation. In the creative context, this can mean that the creator is both the producer and consumer of his own work, using his creative intuition and self-commissioning to produce original and unique content that is also appreciated by others. These practices can help creators gain more control over their creative process, explore original and innovative ideas, and create content that is relevant and engaging to other users.

Keywords: self-commission; creative intuition; prosumer; creativity; product design; design practice.

Introducción

En diseño industrial, el autoencargo se refiere a un proyecto personal que un diseñador se asigna a sí mismo, en lugar de tener un encargo o brief de empresa (Massaguer, 2022). Se trata de un proyecto en el que el diseñador define sus propios objetivos y necesidades, trabajando para desarrollar un producto o solución que las satisfaga. Esta modalidad proyectual es una forma efectiva para que los diseñadores experimenten con nuevas ideas, técnicas y materiales, y para que exploren áreas que les interesen a nivel personal. A través del autoencargo, los diseñadores tienen más libertad para expresarse, a modo de gimnasia creativa (Pelta, 2010), para desarrollar su portafolio y demostrar su capacidad para generar ideas y soluciones de diseño originales (Alfalah, 2018). Es habitual que el diseñador explore durante un tiempo en el autoencargo, ya sea como satisfacción de una idea que pueden ser sus señas de identidad corporativa, su propia imagen, su estudio como espacio de trabajo, sus materiales y herramientas de trabajo, sus productos promocionales, etc (Camillini & Pierini, 2016). El autoencargo se distingue por su capacidad para abordar necesidades personales y específicas, lo cual implica que cada diseñador afronta el problema desde su propia experiencia, incorporando requisitos individuales y evitando la necesidad de universalizar el diseño con el fin de crear soluciones ampliamente aplicables a diversos usuarios. En este sentido, se resalta aún más la idea de que el diseñador genera una solución a medida, personalizada y altamente adaptada, reconociendo que otros individuos pueden tener necesidades

y preferencias distintas que requerirán enfoques diferenciados. Esta perspectiva subraya la naturaleza única y diversa del proceso de diseño, enfatizando la importancia de considerar la singularidad de cada usuario en el desarrollo de soluciones innovadoras y significativas (Ruiz, 2014).

Por otro lado, la intuición es la posibilidad de tomar decisiones basadas en la experiencia previa y la comprensión rápida de una determinada situación. La intuición creativa es una forma de pensamiento no lineal que se basa en la conexión y la síntesis de ideas y experiencias aparentemente no relacionadas (Gabora, 2010). También, representa la capacidad de confiar en la inspiración previa y las ideas que surgen de manera espontánea, sin depender de métodos creativos tradicionales (Csikszentmihalyi, 1997; Dijksterhuis, 2004; Sawyer, 2011). Los beneficios de la intuición en los primeros momentos de la concepción de un producto son la aceleración y mejora en la toma de decisiones (Klein, 2003), resolver problemas poco estructurados de manera creativa (Dijksterhuis & Meurs, 2006), el potencial de obtener un producto de mayor calidad y una anticipación para la planificación de nuevos productos. Coloquialmente, la intuición también representa un sentimiento que puede ir en contra de lo razonable y lo establecido, como un instinto o impulso de realizar un cambio crítico que de no seguirlo resultará ser un error (Sadler-Smith & Shefy, 2004). Muchos diseñadores, artistas y creativos confían en su intuición para generar nuevas ideas y enfoques que pueden ser difíciles de descubrir a través de un proceso de pensamiento más estructurado (Finke et al., 1996). Sin embargo, aunque la intuición

creativa puede ser una herramienta poderosa, no es infalible y puede ser afectada por prejuicios, preferencias personales y sesgos cognitivos. Por lo tanto, es importante combinar la intuición con otros métodos creativos y de pensamiento crítico para asegurarse de que las ideas sean viables y efectivas en la práctica (Dayan & Di Benedetto, 2011).

El concepto de “prosumer”, una fusión de las palabras productor y consumidor (Ritzer, 2010; Toffler, 1980), refiere a la práctica en la cual los usuarios se convierten en productores activos de bienes, en lugar de limitarse a consumir lo que las empresas les ofrecen (Asión Suñer & López Forniés, 2022; Blättel-Mink et al., 2010). Toffler (1980), en su libro “La tercera ola”, describe un importante cambio social donde el hogar se convierte en un núcleo central para las relaciones familiares, amistades y vecindarios. En este nuevo contexto, se observa un aumento en el número de personas que actúan como prosumers. Esta tendencia refleja un énfasis en la individualización y personalización de las experiencias. Paralelamente, se observan procesos dominantes como la desindustrialización, que implica una disminución de grandes fábricas, así como la desmercantilización y la desmasificación de los mercados, lo cual implica una menor homogeneidad y mayor diversidad en las opciones disponibles.

En este sentido, se puede considerar que el prosumer, de manera intuitiva y sin ser plenamente consciente, realiza un autoencargo al responder a una necesidad individual. Al asumir un papel activo en la producción de bienes y servicios, el prosumer se encuentra en sintonía con el espíritu del autoencargo y la creación propia. A través de su participación directa, el prosumer tiene la capacidad de satisfacer sus necesidades personales de manera más precisa y adaptada, sin depender exclusivamente de los productos estandarizados que se encuentran en el mercado. Esta intersección entre el prosumer y el autoencargo destaca la capacidad inherente del individuo para reconocer y abordar sus propias necesidades creativas, impulsando así la

búsqueda de soluciones personalizadas y auténticas. En última instancia, se evidencia que el prosumer, sin darse cuenta, se involucra en un proceso de autoencargo al ejercer su creatividad y responder a sus propias demandas, desempeñando así un papel significativo en la configuración y personalización de su experiencia como consumidor y productor.

En el contexto creativo, esto puede significar que el creador es tanto el productor como el consumidor de su propio trabajo, que necesita experimentar la transgresión, superar las debilidades y adquirir competencias clave personales, utilizando el autoencargo y su intuición creativa para producir contenido original y único que también es apreciado por otros (Lebuda & Csikszentmihalyi, 2017). Estas tres prácticas ayudan a los creadores a tener un mayor control sobre su proceso creativo, a obtener innovación y hacer mejor su trabajo dado que es el trabajo que realmente aman (Sternberg & Lubart, 1996). La personalización se ha convertido en una necesidad en la producción de bienes, ya que la estandarización de los productos no puede satisfacer las necesidades y deseos individuales de cada consumidor (Chandler & Chen, 2015; Toffler, 1980). El objeto personalizado sería aquel que tiene una alta personalización adaptando los artefactos a las necesidades y preferencias particulares de cada persona, y que está adaptado la tecnología para ser producido con costes similares a los productos estandarizados (Norman, 2005). Sin embargo, el prosumer puede adoptar la decisión de diseñar su producto personalizado con el que se establecen relaciones más duraderas, permitiendo ampliar su vida útil y postergar su obsolescencia (Chapman, 2015).

Este enfoque ha ganado relevancia debido a que los productos han tendido a ser más masivos y estandarizados. En la actualidad, la personalización desempeña un papel fundamental en muchos procesos de diseño y fabricación gracias a la tecnología. Los consumidores tienen cada vez más opciones y herramientas para personalizar productos y servicios de acuerdo con sus necesidades y preferencias individuales.

Esto ha llevado a un mayor énfasis en la experiencia del usuario y en la capacidad de satisfacer las necesidades y gustos particulares de cada consumidor (Franke & Piller, 2004).

Este trabajo estudia los resultados del proceso creativo aplicado por diseñadores noveles al diseño de un objeto personalizado, tomando como ejemplos resultados de perfiles diferentes de diseñador profesional y prosumer/maker. El objetivo es contrastar los puntos comunes del proceso, y si las diferencias que se detectan provienen del perfil personal, del diseño que pretenden o de las herramientas que tienen a su alcance. Una vez analizados se comparan con los resultados de autoencargo realizados por diseñadores noveles de los que se tiene caracterizado el proceso creativo desde la propuesta hasta la prueba de un prototipo y la definición formal.

El interés de esta contribución recae en la orientación de los perfiles analizados, todos ellos con necesidades particulares, hacia su solución específica, con un diseño propio o a medida, pero con procesos similares. Con las nuevas formas de fabricación digital, mediante herramientas de fabricación y prototipado, bricolaje o Do It Yourself (DIY), el diseñador profesional y novel tienen mayor autonomía para desarrollar su creatividad y experimentar creando sus diseños, validando sus ideas y resolviendo sus necesidades particulares (Gershenfeld, 2005).

Metodología

Este estudio se ha centrado en una investigación bibliográfica y en una búsqueda de casos de autoencargo con el objetivo de explorar la posible relación entre el autoencargo y el concepto de prosumer, con el propósito de comprender si los procesos creativos llevados a cabo por diseñadores en un autoencargo guardan alguna similitud con aquellos realizados por el grupo de prosumers.

Se ha recurrido a ejemplos publicados abiertamente por Diseñadores Profesionales (DP) y PROsumers (PR) con el fin de

ilustrar y enriquecer el conocimiento de los estudiantes de diseño o Diseñadores Noveles (DN), tratando productos similares y dentro de un mismo sector de actividad como se puede ver en la Tabla 1. Sin embargo, se ha buscado fomentar la libertad en el proceso creativo de los diseñadores noveles, tanto en la selección del objeto a diseñar como en el propio desarrollo del proceso, incluyendo las distintas fases, métodos y técnicas utilizados. Mediante este enfoque, se promueve la autonomía y la originalidad en el proceso creativo de los DN, incentivándolos a buscar soluciones novedosas.

La investigación inicial relaciona el autoencargo en el ámbito del diseño, sea académico o no, con el proceso creativo intuitivo, la fabricación o la materialización del objeto a diseñar. Los casos servirán para documentar y comparar los elementos comunes y diferencias. Los casos de profesionales y de prosumers se van a utilizar a modo de ejemplo para comparar los resultados del perfil de los diseñadores noveles.

De los diseñadores profesionales se analizan los productos realizados como autoencargo, los resultados que persiguen y que aportan a su profesión, estos casos se han extraído de revistas online de diseño como Core77, DesignBoom, Yanko Design, Experimenta, etc. Para el perfil prosumer se buscan sus resultados publicados en la red en webs como Instructables Makezine, Thingiverse, Hackaday, Craftsby, entre otras, mostrando que tipos de objetos o diseños hacen, que metas persiguen, sus métodos, y los resultados obtenidos.

En el caso de diseñador novel se utilizan los resultados de una experiencia con 74 estudiantes de segundo curso de un grado en Ingeniería de Diseño Industrial y Desarrollo de Producto, en la asignatura Taller de Diseño III, Creatividad, con 74 estudiantes, y realizando un trabajo específico denominado Proyecto Prosumer, se estudiarán sus trabajos académicos como si de un autoencargo se tratase, el proceso desarrollado, los objetivos personales y académicos y los resultados

finales. A los estudiantes se les enseña la definición de prosumer y el significado de autoencargo (Asión-Suñer, 2021).

En la figura 1 se muestra el modelo propuesto a los DN. El autoencargo es la identificación de una necesidad individual y concreta dentro de su entorno doméstico, con el objetivo de diseñar un producto que resuelva dicho problema. Se hace hincapié en la importancia de que cada DN identifique su problema personal destacando así su capacidad para detectar necesidades propias y resolverlas de manera autónoma a través del enfoque del diseño prosumer. Se les instruye en adoptar el rol del prosumer ideal, siendo diseñadores, productores y consumidores; asumiendo la responsabilidad de crear y fabricar la mayor parte de su producto, evitando así la necesidad de adquirirlo de terceros.

El proceso creativo es dirigido inicialmente al solicitar que documenten su problema a través de fotografías y videos que muestren el contexto en el cual se presenta el problema. A partir de este punto cada DN decide de manera intuitiva y personalizada como afrontar la resolución del problema. En la fase de ideación cada DN se aproxima a las soluciones por medio de experimentación con prototipos rápidos para validar sus primeras ideas.

El proyecto implica la creación de un prototipo funcional que demuestre la resolución del problema y el desarrollo de una estética definida por medio de una metáfora obtenida por el análisis de un audiovisual en el que encuentran atributos con los que vestir el prototipo funcional. Los requisitos para los estudiantes son sencillos: al menos una pieza del producto debe ser diseñada y fabricada por ellos mismos utilizando tecnologías

manuales y/o de fabricación digital, y se les recomienda utilizar materiales reciclados de su propio entorno doméstico en la medida de lo posible. Los resultados del primer prototipo y las primeras pruebas deben servir para mejorar el diseño, la funcionalidad, la utilidad, la ergonomía y dimensionar el objeto o seleccionar los materiales (López-Forniés, 2021).

Esta metodología fomenta la independencia y la creatividad individual, permitiendo a los estudiantes convertirse en agentes activos en la resolución de sus propios problemas, mientras aplican los principios del diseño y la fabricación digital.

Modelos de procesos creativos de autoencargo.

En la Tabla 1 se presentan 6 ejemplos de diseño por parte de diseñadores profesionales y prosumer, se utilizan como referencia para los estudiantes a modo de ejemplo y de referencia para el análisis comparativo. Se han elegido estos casos por representar un producto funcionalmente complejo (diseño de materiales y electrónica) con proceso de desarrollo muy elaborado, un producto en una pieza única, aunque se construya con diversos materiales, relacionado con el ocio, el deporte y las aficiones (tablas de surf) y un ejemplo de diseño gráfico (experimental en los profesionales y doméstico en las camisetas).

Las investigaciones de Nienke Hoogvliet con algas marinas han resultado en un material textil similar al algodón con mejores rendimientos y más sostenible por la reutilización de redes de pesca o similares. Otra de sus investigaciones ha finalizado en un nuevo proceso de curtido de cuero de pieles de pescado. Tanto su proceso creativo como el de diseño es altamente intuitivo y

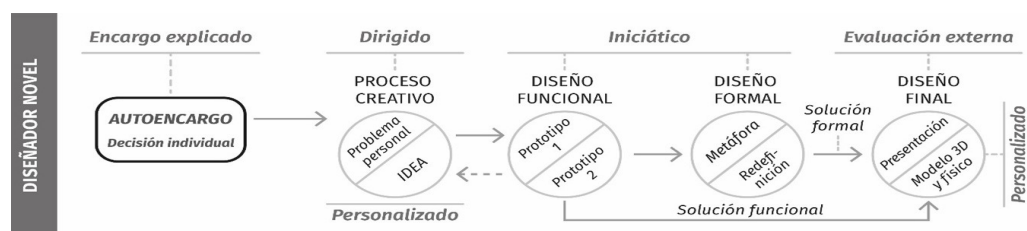


Figura 1. Modelo mostrado a los diseñadores noveles, para realizar su proceso creativo de autoencargo. Fuente: elaboración propia.

Tabla 1. Productos de autoencargo para Diseñadores Profesionales (DP) y Prosumers (PR). Fuente: elaboración propia

	Diseñador/Estudio	Producto	Sector
DP	Nienke Hoogvliet (2023)	Material textil Fish Leather (Studio Nienke Hoogvliet, 2017)	Textil/mobiliario
	Agote Surfboards Triangle Studio (TRIANGLE-STUDIO, 2023)	Tablas de surf a medida Try Angle Paper (Eyeondesign, 2015).	Ocio y deporte Diseño gráfico
PR	Engineer42 (2023) Memestra (2022) Varios diseñadores	Sensor de CO2 Tabla de surf artesanal Camisetas personalizadas	Electrónica Ocio y deporte Diseño gráfico

sus logros derivan de los pequeños avances en su experimentación. La estética de sus diseños está «delicadamente cuidada y su presentación es impactante» (Hoogvliet, 2023).

El caso de los diseñadores y artesanos de tablas de surf, como Agote Surfboards (Basque Country Surf Company, 2023) o Surferrule (2023), es interesante, ya que cubren los tres temas tratados en este trabajo el autoencargo, el prosumer y la personalización. Además, afirman que sus periodos sin encargos los dedican a desarrollar sus ideas para validar sus diseños que después pueden dejar para probar y/o vender. Nacho Agote, llamado el lutier del mar, tiene como filosofía de trabajo superar la dimensión del objeto, y que sus tablas tengan un valor superior a la práctica del surf. Su labor es muy vocacional, con muy pocas unidades al año y una gran dedicación y cuidado.

En un estudio de Corea del Sur los diseñadores han complementado su modesto portafolio con una publicación trimestral ingeniosamente titulada Try Angle Paper (Eyeondesign, 2015). El proyecto autoencargado les da una oportunidad para hacer cosas que quizás no podrían hacer para los clientes, como experimentar con tipografía, hacer su propio papel y crear productos que venden online. Además, su autoencargo actúa como un elemento promocional gratuito de lo que el estudio puede hacer, funciona y compensa el tiempo invertido.

En el grupo de los prosumer, maker y aficionados al DIY según la página de Instructables (Autodesk, 2023) existen

5 grandes grupos de productos para realizar el autoencargo, son los productos que introducen una pequeña electrónica, productos para el hogar, productos realizados artesanalmente, productos para el exterior (jardín, terraza, etc.) y las recetas de cocina. En la web de Makezine (Make Community LLC, 2023) tienen 8 categorías donde encontramos las siguientes diferencias, fabricación digital, drones vehículos, ciencia y tecnología, proyectos de taller. En la página de la comunidad Thingiverse se agrupan en nueve categorías con las siguientes diferencias: aficiones, aprendizaje, herramientas, artes, complementos, juegos y juguetes. Otras páginas como hackster.io (Avnet Inc., 2023) clasifican los proyectos por la dificultad, el conocimiento inicial antes de hacer el autoencargo.

El primer ejemplo es la experimentación con componentes electrónicos en el que se diseña un sensor de CO2 (Engineer42, 2023) que se ha convertido en un estándar por el COVID-19. Con el lema “diseña su propio sensor de CO2”, se explica en el proyecto de manera completa la implementación, desde la lista de componentes y el montaje hasta el ajuste. Si se continúa en la búsqueda en la web de Instructables, se observa que hay proyectos similares que muestran características propias en el display de información con leds, tiras de leds o pantallas gráficas, donde cada una necesita una programación diferente y, por lo tanto, implica un aprendizaje y un avance en el conocimiento del prosumer que se está generando su prototipo. En este tipo de proyectos, el acabado final, el diseño formal y la presentación, no son lo más

importante y en ocasiones desmerecen el valor funcional del prototipo.

El segundo ejemplo trata de un diseñador de tablas de surf de madera (Memestra, 2022) que realiza de manera artesanal y que muestra en la web de manera abierta para que quien quiera pueda hacer su propia tabla en el taller o en su garaje. En su diseño, que ha personalizado del aprendizaje de otros diseñadores, incluye mejoras a la medida de sus necesidades y comparte toda la información para otros puedan disfrutar de construir su propia tabla, llegando a una experiencia autotélica en la que se comparte el placer de construir con el disfrutar del deporte. Cabe indicar que la experiencia y el conocimiento de este diseñador es alto o nivel experto y sus materiales y herramientas de fabricación son de categoría cuasi profesional. Los acabados son profesionales, aunque se notan detalles artesanales.

El tercer ejemplo es para diseñadores de camisetas que hacen su propio marcado por medio de varias tecnologías. No se trata de un diseñador en concreto, sino de un grupo de aficionados que hacen sus propias creaciones y las comparten mostrando el proceso de diseño y ejecución. La diversidad de opciones creativas es ilimitada dado que dependerá del gusto personal de la persona que diseñe, y la técnica que ejecute o que pida para que una empresa ejecute por ellos. En muchos ejemplos se aprecian las limitaciones de las técnicas caseras frente a las profesionales de serigrafía o transfer.

En la Figura 2, se aprecian estos procesos y las distintas fases en las que se manifiestan el autoencargo, la intuición y la personalización. Para el diseñador profesional el autoencargo se hace evidente desde el inicio del proceso creativo, en el momento en que el diseñador asume la responsabilidad de resolver una necesidad o problema personal. Este enfoque implica un alto grado de autonomía y reflexión, ya que cada diseñador se enfrenta a su propia experiencia y requerimientos individuales, evitando así la universalización del diseño y permitiendo una solución personalizada.

El pensamiento intuitivo se manifiesta para el profesional en la fase creativa y se basa en su propio conocimiento como si trabajase en un proyecto en caja negra. La personalización se manifiesta en las fases finales del proceso creativo. Sin embargo, esta personalización está latente desde el inicio del proyecto, es perseguida de manera deliberada por el diseñador profesional, representa la imagen de su objetivo, y adaptada por el prosumer, se debe adaptar a sus necesidades específicas y cumplir con los requisitos. La personalización se convierte en una manera de asegurar la relevancia y el atractivo del producto final para los consumidores.

Para el prosumer la conciencia de autoencargo aparece tras una serie de tentativas y después se aplica el pensamiento intuitivo durante todo el proceso, desde la fase cíclica de iteraciones en las que analiza el problema y se

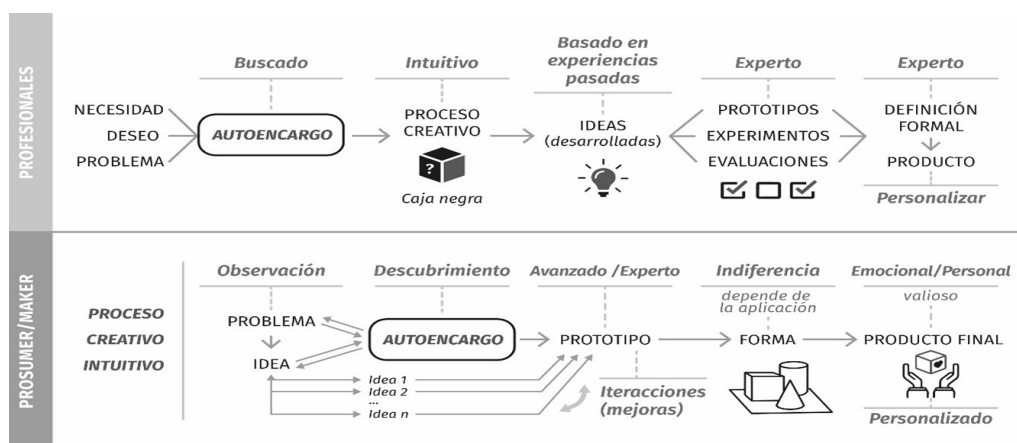


Figura 2. Modelos de procesos creativos de autoencargo para Diseñador Profesional y Prosumer.
Fuente: elaboración propia

realimenta por medio de ideas que van de la observación al descubrimiento. Una vez alcanzada una idea y validada por medio de un prototipo, o la edición del mismo, se establece un proceso de mejora que lleva el diseño formal y la finalización del producto que adquiere un valor emocional personal.

A los DN se les ha mostrado, además de estos, otros ejemplos, siempre dentro de un entorno más próximo y doméstico, con diferentes grados de dificultad en la definición, el desarrollo, la construcción y el acabado.

Resultados

En la Tabla 2, observamos los resultados de la fase de búsqueda de casos y ejemplos de DP y PR, y los del análisis de los proyectos de los DN; se citan: principales factores que afectan al autoencargo, el tipo de proceso creativo y los resultados obtenidos. Respecto a las motivaciones predominan las que producen beneficio para uno mismo como la autoevaluación, la autorrealización, la experiencia autotética, la marca personal, la autonomía, etc.

El autoencargo tiene el potencial de llevar a un proceso de diseño debido a la necesidad de una experiencia autotética, en la que el diseñador disfruta por el propio placer de hacer lo que está haciendo, no disfruta porque luego obtenga una recompensa,

sino que disfruta porque realmente lo que está haciendo le produce placer y es capaz de sumergirse en un estado de fluidez o Flow (Csikszentmihalyi, 1997).

Los casos analizados de diseñadores profesionales reflejan motivaciones de autoencargo variadas (Walsh, 2019) dividiéndose en dos grupos. El primero, apunta a la personalización de su imagen para presentarse al exterior de manera única y destacar entre otros profesionales de su campo. El segundo, promocionar sus productos e ideas mostrando un estilo propio. El autoencargo de proyectos para promocionar sus propias ideas les permite tener mayor control sobre el proceso creativo y presentar productos que reflejen su visión personal mostrando su capacidad para resolver problemas y crear soluciones innovadoras, experimentando con nuevas técnicas y mejorando su reputación ante clientes o colaboradores (Mineyama-Smithson, 2023). Se puede decir que la resolución de las situaciones iniciales, las ideas y soluciones están resueltas con experiencia y según un proceso intuitivo basado en la experimentación, el prototipado y las evaluaciones sucesivas para la mejora de las primeras ideas. Respecto a los acabados formales y los detalles del diseño final, están cuidados y son valiosos ya que representan su propia imagen, su toque personal y promoción hacia el exterior. El proceso creativo es experimental, aunque

Tabla 2. Factores del autoencargo. Inicio, proceso y resultado. Fuente: elaboración propia.

Factor	Detonante o necesidad inicial (Autoencargo)	Proceso Creativo	Resultados obtenidos
DP	Dar la oportunidad a algo vanguardista, divertido o que apasione. Nutrir el alma creativa Mejorar las relaciones comerciales. Conexión emocional Autoevaluación. Valorar competencias y descubrir fortalezas personales Autorrealización y ambición personal. Expansión en RRSS Comercializar a través de productores de diseño Diseño experimental (Hoogvliet, 2023) Experiencia Autotética. Disfrutar de tiempo no productivo Cambiar orientación profesional (Disrupt Design LLC, 2023)	Intuitivo y en caja negra Experimental Diversión Basado en experiencias previas	Depurados y alta calidad en los acabados Tarjeta de presentación
PR	Experiencia Autotética Resolver una necesidad personal insatisfecha Aprendizaje autónomo. Aprender una determinada materia Fabricación personal y fabricación digital Compartir. Sentimiento de comunidad	Intuitivo en todo el proceso, incluso tras finalizar Copia y transformación de ejemplos Iterativo. Prueba y error	Poco cuidados en los detalles cuando es para autoconsumo Es más importante el vínculo afectivo
DN	Creación de un portfolio Formación como diseñadores (Walden & Kokotovich, 2012) Conocer una materia específica relacionada con diseño (Walden & Kokotovich, 2012) Crear su propia marca personal Autonomía en su proceso creativo y de diseño Emprendimiento (Universidad Politécnica de Valencia, 2023)	Muy diverso, sin patrón Tensión en la toma de decisiones Problemas mal definidos Los que experimentan resuelven mejor	Muy básicos y descuidados No hay preocupación por el detalle Es suficiente con que funcione medianamente bien No tiene el mismo valor que para el profesional

los conocimientos previos tienen un gran peso en las decisiones.

Respecto al grupo de prosumer o makers se observa que el autoencargo aparece por dos motivos: bien por la detección de un problema o una necesidad o bien por una idea intuitiva, podemos decir que el autoencargo viene de un descubrimiento. El proceso creativo es intuitivo, se basa en una serie de intentos de prueba-error que le lleva a un nivel de prototipado avanzado (si es que necesita aprender algo concreto) o experto si domina el campo en el que está diseñando. Respecto a la forma de los objetos, es algo que se relega a un segundo lugar salvo en los casos en los que los productos vayan a ser visibles por terceros; este aspecto parece indiferente y se sienten cómodos con acabados del tipo artesanal y además sienten que es algo que pueden rehacer y mejorar en una fase posterior. El valor del objeto diseñado está en el valor emocional, en la satisfacción de una necesidad no cubierta de otro modo, una adaptación a medida o la superación de un reto personal.

Para el perfil prosumer, la vivencia autotélica puede ser una fuente de satisfacción y realización personal. Al estar involucrado en todo el proceso de diseño y producción, desde la concepción de la idea hasta la realización del objeto final, el prosumer puede sentir una conexión única con su trabajo y con su capacidad de creación. Esta puede ser especialmente gratificante cuando el objeto diseñado tiene un alto nivel de complejidad o requiere de habilidades y conocimientos especializados para su realización (Csikszentmihalyi, 1997). Por medio de la fabricación personal, el prosumer crea sus propios objetos utilizando herramientas y técnicas manuales tradicionales, como la carpintería, la herrería, la costura o la cerámica (Mota, 2011). Por otro lado, la fabricación digital implica el uso de tecnologías digitales, como impresoras 3D, cortadoras láser y máquinas CNC, para producir objetos. Esto ofrece a los prosumers la capacidad de crear objetos complejos y detallados de manera más rápida y precisa, lo que puede

aumentar su eficiencia y creatividad (Yoo et al., 2016).

En el grupo de diseñadores noveles, el autoencargo es algo impuesto y dirigido para que puedan aprender este concepto (aunque algunos ya lo conocen), se les da la opción de elegir el problema, cotidiano y personal, para que puedan comprender el concepto de prosumer. Su proceso creativo es dirigido y pautado, aunque abierto, aprenden a trabajar con problemas analizando las causas y a profundizar en los condicionantes de diseño, mediante el registro con fotografías y videos.

Los estudiantes comenzaron con un proceso de detección de los problemas cotidianos a resolver, utilizaron principalmente técnicas propias basadas en el Shadowing o el User's journey (Interaction Design Foundation, 2023), creando una tabla que repasa las acciones cotidianas que les resultan molestas durante la semana en diferentes momentos o en diferentes espacios y que les gustaría eliminar. Los ejemplos vistos y la revisión de sus día a día les permite decidir que producto diseñar, aunque este es el punto más crítico para ellos por estar obligados a decidir.

Sus motivaciones personales se vinculan a su portfolio o carta de presentación futura, el conocimiento de una materia específica, hacer un proyecto relacionado con sus aficiones o crear una marca personal, siendo similares a las de los DP y PR. Las motivaciones de carácter académico son la formación como diseñadores y ganar autonomía en su proceso creativo. Finalmente, hay una motivación algo remota por llevar la idea a la producción y convertir su proyecto en una empresa por medio de emprendimiento (Universidad Politécnica de Valencia, 2023), que podría estar relacionada con la comercialización de objetos por parte de DP o del emprendimiento del PR.

La generación de ideas también es dirigida por medio del prototipo inicial que les obliga a una autoevaluación. El primer prototipo es iniciático, en muchos casos es la primera vez que hacen un modelo

funcional, a diferencia de los DP y los PR que trabajan inmediatamente con prototipos a los DN hay que insistirles para que los realicen y les saquen provecho. Sin embargo, les ayuda a redefinir el problema e iterar en las ideas para mejorar hasta llegar al segundo prototipo que los llevara a la solución, como haría un PR. Para el desarrollo formal se recomienda trabajar con metáforas y con la redefinición de conceptos observados en otros ámbitos. Su diseño final de evalúa de manera externa, por parte de los supervisores o profesores, que para ellos es una medida del logro de su diseño, a diferencia con los DP y PR que hacen autoevaluación.

En el caso de los diseñadores noveles se estudiaron 74 casos de autoencargo, en un pequeño proyecto denominado prosumer. En la selección del objeto a diseñar se han encontrado 13 ámbitos de aplicación doméstica o cotidiana, ver Tabla 3, existen propuestas repetidas en algunos grupos. La diversidad de productos es muy alta, con aplicaciones interesantes y novedosas como un lavavajillas manual o un tacón plegable adaptable a zapatos planos y otras muy básicas y esenciales como la organización y el orden en la habitación.

Para evidenciar el problema, han fotografiado la situación real de uso que les resulta molesta y describir las razones y los condicionantes que generan el problema. En la Figura 3 se observa la secuencia realizada a modo de secuencia de uso como si fuera un storyboard. La descripción del problema la completan por medio de una serie de preguntas similares a las técnicas creativas de 5W-H, el porqué de las cosas, etc. (Neuronilla Creatividad Integral, 2023). De este modo el problema está completamente definido en su contexto, con los factores de diseño y las variables que lo condicionan.

El proceso continúa con una generación de ideas individual y libre, que puede ser a través de técnicas textuales o graficas. Se recomienda que utilicen ambas para comenzar a visualizar la solución por medio de imágenes. Las técnicas utilizadas principalmente son los microdibujos

Tabla 3. Resultados de los objetos diseñados clasificados por ámbito de aplicación. Fuente: Elaboración propia.

Ámbito	Objeto
Almacenamiento y organización	Expositor bisutería. Organizador camisetas. Organizador de bolso. Organizador material ilustración. Organizador objetos personales. Organizador prendas para armario. Tendedor (de interior, de radiador y plegable)
Aseo e higiene personal	Estuche lentillas. Estuche limpiador férula dental. Estuche maquillaje. Quita-pelos para cepillo
Baño	Cierre cortinas de ducha. Filtro de pelos para ducha. No mojarse las mangas en el lavabo
Bricolaje	Cubierta cortacésped
Complementos	Empuñadura-funda de paraguas. Extensión paraguas para dos. Funda de móvil con alojamiento para tarjetas. Inmovilizador interior inflable para maletas. Llavero protector puertas
Deportes	Enrollador vendas boxeo
Electrónica	Organizador cables de ordenador. Bandeja móvil y pertenencias. Fundar portátil. Lámpara despertador para móvil. Soporte mandos a distancia. Soporte mandos consola. Soporte ordenador portátil. Soporte ratón sobre portátil. Soporte tableta
Limpieza hogar	Cuencos limpieza. Recogedor y cepillo para escoba
Menaje	Asa para transporte de pesos. Clasificador residuos domésticos. Compactador de latas. Contenedor hermético con válvula de vacío. Dosificador de cereales. Emparejador de calcetines para lavadora. Especiero múltiple. Faja antigoteo para tazas. Funda protectora de sandwichera. Lavavajillas. Organizador de especias. Organizador hilos de costura. Organizador de útiles de cocina. Pelador fruta. Pinza para platos calientes. Soporte cuchara para tazas
Mobiliario	Apoyo pies para sillas altas. Colgador paraguas. Dispositivo antivuelco silla oficina. Lámpara orientable. Mesita auxiliar cama. Soporte de secador de pelo. Soporte despertador. Soporte partituras. Superficie multifuncional para lavabo. Trinquete o freno para persiana
Motor	Funda casco para mochilas. Soporte calentador taza para coches
Ropa	Cordón cierre cremalleras de espalda. Percha (de viaje troquelada, extensible, para tendedor). Tacón plegable
Textil hogar	Cojín protege gafas



Figura 3. Ejemplo de la definición del problema (autor: Matthis Bellanger).

para conseguir bocetos y variaciones rápidamente y el morphing utilizando las fotografías que han tomado (Neuronilla Creatividad Integral, 2023).

Una vez que las ideas están definidas pasan a desarrollar un prototipo para explorar la funcionalidad y la factibilidad. Los prototipos se realizan con materiales reciclados para poder editarlos y hacer cambios sobre las observaciones. El resultado es una aproximación dimensional del objeto y el tipo de materiales necesarios para el prototipo a validar. Las primeras pruebas permiten introducir mejoras de uso, funcionales, de materiales y estructura, ergonómicas, etc.

Respecto a los prototipos un 17% no ha modificado el prototipo inicial, un 60% ha realizado un prototipo incluyendo variaciones o mejoras y un 23% ha realizado varios prototipos en los que ha propuesto cambios. Un 73 % declara que los cambios le han ayudado a mejorar el diseño y un 9% los ha llevado a cambiar el diseño o concepto inicial. En este aspecto los prototipos que les acercan a un proceso experimental y de prueba y error similar a los diseñadores profesionales y prosumers que les permiten mejorar sus diseños, y se corresponde con los resultados de acabados y definición funcional. En la valoración de prototipos como útiles para el proceso creativo, un 27% los valora como muy útil y un 56% lo declara como útil, ninguno declara que no tengan utilidad y tan solo un 17% declara que tiene poca o utilidad o no sabe que contestar. Los datos se han tomado del proyecto de Innovación Docente “Seguimiento y mejora de la utilización del prototipado como herramienta de aprendizaje del proceso de diseño en los primeros cursos del Grado en Ingeniería de Diseño Industrial y Desarrollo de Producto” PIIDUZ_2 Consolidados 916_2022 (Sierra-Pérez, 2022).

Tan solo un 30% de los estudiantes han utilizado herramientas de fabricación digital para realizar sus prototipos. Es algo apreciable en la calidad de la fabricación y los acabados, los más artesanales funcionan peor y tiene un aspecto más

frágil. Los fabricados con herramientas FabLab se corresponden con mejores acabados y con mejoras funcionales debidas al mayor número de pruebas. Se replica aquí el carácter iterativo que aplican los prosumers para ir mejorando su diseño con ediciones y mejoras en sus prototipos.

El segundo prototipo permite evaluar el diseño e introducir las mejoras necesarias y evidenciar el funcionamiento por medio de una secuencia de uso con fotografías y videos. En la Figura 4 se observa el segundo prototipo realizado con cartón-pluma, sobre el que se han realizado algunos cambios y se verificado el funcionamiento. Se observa que el acabado se realiza con pasta de modelar, el objeto tiene un acabado no definitivo y necesita una evolución en cuanto a los acabados.



Figura 4. Imágenes del segundo prototipo y su uso (autor: Matthias Bellanger).

Para el diseño formal trabajan con dos técnicas como son la metáfora y la redefinición. La técnica de la metáfora (Lubart & Getz, 1997) implica la comparación de dos cosas aparentemente no relacionadas, para encontrar similitudes o patrones que permitan una mejor comprensión del tema en cuestión. Estas técnicas se utilizan en muchos campos creativos, incluyendo el diseño, la publicidad, la literatura y la poesía. La metáfora les permite encontrar un elemento que se vincule a su objeto funcional y por medio de la redefinición podrán dotar a su prototipo de atributos formales y una estética propia. En la redefinición el diseñador debe tomar un audiovisual de corta duración definido por su metáfora y de este extraer elementos

como el ritmo, el color, las formas, la música, para asignarlos como atributos en su definición formal. Finalmente hacen una presentación de su diseño final por medio de una representación 3D, digital o con un modelo físico, y unos renders o fotografías. En la solución final deben coexistir en armonía la definición funcional y la formal, por lo tanto, las dimensiones del prototipo y las proporciones del objeto final deben estar al unísono.

Los resultados formales, la estética, los acabados y los detalles son pobres y poco evolucionados, similares a un PR y al contrario de los que hace un DP, la experiencia previa de DP y PR es el elemento diferenciador respecto a los DN. Tan solo los DN que en la fase de experimentación han evolucionado y perfeccionado sus prototipos han conseguido buenos resultados formales. El nivel de dificultad y complejidad del objeto también influye ya que no es comparable un lavavajillas con un soporte para paraguas.

Conclusiones

Las diferencias entre encargo de empresa y autoencargo personal es clara. El primero implica riesgos y responsabilidades mientras que el segundo se realiza por una decisión de satisfacer una necesidad o deseo personal, no se cubren de la misma manera. En el autoencargo los riesgos se asumen como propios y con bajo impacto.

Los tres grupos terminan consumiendo sus productos de autoencargo, cada uno con objetivos distintos, por tanto, el autoencargo es una forma de convertirse en un prosumer, estableciendo un proceso creativo propio, que puede ser más o menos intuitivo dependiendo de la experiencia de cada perfil. Para el DN la libertad de este proceso le permite explorar su intuición creativa y responder a necesidades individuales de manera personalizada, siguiendo un enfoque similar al del prosumer incluso si no son conscientes de ello. La falta de experiencia hace que esta libertad creativa tensione al DN por no tener un camino fácil por el que continuar.

Al fomentar la conexión entre el autoencargo y el carácter prosumer, se abre un camino hacia la comprensión de los procesos creativos intuitivos impulsados por necesidades individuales y la exploración de nuevas posibilidades en el ámbito del diseño.

Muchos diseños considerados buen diseño (Erlhoff et al., 2008) son una elegante materialización del aprendizaje que los diseñadores han adquirido por el continuo proceso de prueba y error derivado de sus intuiciones y de las habilidades que experimentan con las soluciones alternativas generadas.

Los prosumers se sienten satisfechos de sus resultados funcionales independientemente de su apariencia formal, ganan confianza para hacer nuevos proyectos y emocionalmente crean un vínculo con esos objetos (Chapman, 2015). El diseñador profesional de una manera paralela tiene su estudio o su taller en el que recrean estas mismas sensaciones. Es importante que el DN de una manera guiada o voluntaria experimente con este tipo de proyecto para que sus procesos creativos y de diseño mejoren, y su pensamiento intuitivo crezca.

La personalización se convierte en un acto necesario para satisfacer las necesidades individuales y preferencias específicas de cada cliente (Asión-Suñer & López-Forniés, 2021). Sin embargo, en el autoencargo la personalización es, a menudo, parte de la necesidad inicial. Todos los perfiles han desarrollado sus objetos con un alto grado de personalización que es un rasgo característico del ámbito maker o prosumer.

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Self-commissioning, Intuition and Prosumer | Autoencargo, Intuición y Prosumer

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Resumen

El autoencargo en diseño se refiere a la práctica de establecer objetivos y metas para uno mismo en lugar de tener un encargo o brief de empresa. En el autoencargo el creador tiene mayor control sobre el proceso creativo y puede enfocarse en sus propias visiones. La intuición creativa, como capacidad de confiar en la inspiración y las ideas que surgen de manera espontánea, no depende de métodos creativos tradicionales. La combinación de ambas prácticas, autoencargo e intuición creativa, puede permitir una mayor libertad para explorar ideas y enfoques originales. Por otra parte, el “prosumer”, combinación de las palabras productor y consumidor, y que se refiere a la práctica de los usuarios de convertirse en productores activos de productos, en lugar de simplemente consumir lo que les ofrecen las empresas, es un creativo que encaja adecuadamente en el autoencargo y la creación propia. En el contexto creativo, esto puede significar que el creador es tanto el productor como el consumidor de su propio trabajo, utilizando su intuición creativa y autoencargo para producir contenido original y único, que también es apreciado por otros. Estas prácticas pueden ayudar a los creadores a tener un mayor control sobre su proceso creativo, explorar ideas originales e innovadoras, y crear contenido que sea relevante y atractivo para otros usuarios.

Palabras clave: autoencargo; intuición creativa; prosumer; creatividad; diseño de producto; práctica de diseño

Abstract

Self-commissioning in design refers to the practice of setting goals and objectives for oneself rather than having a brief or brief from the company. In self-commission, the creator has more control over the creative process and can focus on his own visions. Creative intuition, as the ability to trust inspiration and ideas that arise spontaneously, is not dependent on traditional creative methods. The combination of both, self-commissioning and creative

intuition, can allow greater freedom to explore original ideas and approaches. On the other hand, the “prosumer”, a combination of the words producer and consumer, and which refers to the practice of users becoming active producers of products, instead of simply consuming what companies offer them, is a creativity that fits appropriately into self-commissioning and own creation. In the creative context, this can mean that the creator is both the producer and consumer of his own work, using his creative intuition and self-commissioning to produce original and unique content that is also appreciated by others. These practices can help creators gain more control over their creative process, explore original and innovative ideas, and create content that is relevant and engaging to other users.

Keywords: self-commissioning; creative intuition; prosumer; creativity; product design; design practice.

Introduction

This design modality is an effective way for designers to experiment with new ideas, techniques and materials, and to explore areas that interest them on a personal level. Through self-commissioning, designers have more freedom to express themselves, in the form of creative gymnastics (Pelta, 2010), to develop their portfolio and demonstrate their ability to generate original design ideas and solutions (Alfalah, 2018). It is common for the designer to explore for a time in self-commissioning, either to satisfy an idea that may be his corporate identity, his own image, his studio as a workspace, his materials and work tools, his promotional products, etc. (Camillini & Pierini, 2016). Self-commissioning is distinguished by its ability to address personal and specific needs, which implies that each designer approaches the problem from their own experience, incorporating individual requirements and avoiding the need to universalize the design creating solutions that are broadly applicable to diverse users. This further emphasizes the idea that the designer generates a bespoke, personalized, and highly tailored solution, recognizing that other individuals may have different needs and preferences that will require different approaches. This perspective underlines the unique and diverse nature of the design process, emphasizing the importance of considering the uniqueness of each user in the development of innovative and meaningful solutions (Ruiz, 2014).

Intuition, on the other hand, is the ability to make decisions based on previous

experience and a quick understanding of a given situation. Creative intuition is a non-linear way of thinking that is based on the connection and synthesis of seemingly unrelated ideas and experiences (Gabora, 2010). It also represents the ability to rely on prior inspiration and ideas that arise spontaneously, without relying on creative methods (Csikszentmihalyi, 1997; Dijksterhuis, 2004; Sawyer, 2011). The benefits of intuition in the early stages of product conception are: accelerated and improved decision making, solving unstructured problems in creative ways, and the potential for a higher quality product and anticipation for the planning of new products. Colloquially, intuition also represents a feeling that may go against what is reasonable and established, such as an instinct or impulse to make a critical change that, if not followed, will turn out to be a mistake (Sadler-Smith & Shefy, 2004). Many designers, artists, and creatives rely on their intuition to generate new ideas and approaches that may be difficult to discover through a more structured thought process (Finke et al., 1996). However, while creative intuition can be a powerful tool, it is not infallible and can be affected by prejudices, personal preferences, and cognitive biases. Therefore, it is important to combine intuition with other creative and critical thinking methods to ensure that ideas are workable and effective in practice (Dayan & Di Benedetto, 2011).

The concept of the “prosumer,” a fusion of the words producer and consumer (Ritzer, 2010; Toffler, 1980), refers to the practice

in which users become active producers of goods, rather than merely consuming what companies offer them (Asión Suñer & López Forniés, 2022; Blättel-Mink et al., 2010). Toffler (1980), in his book “The Third Wave,” describes an important social change where the home becomes a central nucleus for family relationships, friendships, and neighbourhoods. In this new context, there is an increase in the number of people acting as prosumers. This trend reflects an emphasis on individualization and personalization.

In this sense, it can be considered that the prosumer, intuitively and without being fully conscious, carries out a self-entrustment when responding to an individual need. By assuming an active role in the production of goods and services, the prosumer is in tune with the spirit of self-commissioning and self-creation. Through his direct participation, the prosumer has the ability to meet his personal needs in a more precise and adapted way, without depending exclusively on the standardized products found on the market. This intersection of prosumer and self-commissioning highlights the inherent ability of the individual to recognize and address their own creative needs, thus driving the search for authentic, personalized solutions. Ultimately, it becomes clear that the prosumer inadvertently engages in a self-commissioning process by exercising his creativity and responding to his own demands, thus playing a significant role in shaping and personalizing his experience as a consumer and producer.

In the creative context, this can mean that the creator is both the producer and the consumer of their own work, needing to experience transgression, overcome weaknesses, and gain personal key competencies, using self-commissioning and their creative intuition to produce original content and unique that is also appreciated by others (Lebuda & Csikszentmihalyi, 2017). These three practices help creators gain more control over their creative process, gain innovation, and do their work better because it is the work they truly love (Sternberg & Lubart, 1996). Personalization

has become a necessity in the production of goods, since the standardization of products cannot satisfy the individual needs and desires of each consumer (Chandler & Chen, 2015; Toffler, 1980). The personalized object would be one that has a high level of customization, adapting the artifacts to the particular needs and preferences of each person, and that the technology is adapted to be produced with similar costs to standardized products (Norman, 2005). However, the prosumer can make the decision to design their personalized product with which more lasting relationships are established, allowing them to extend their useful life and postpone their obsolescence (Chapman, 2015).

This approach has gained relevance because the products have tended to be more massive and standardized. Today, customization plays a key role in many design and manufacturing processes thanks to technology. Consumers have more and more options and tools to customize products and services according to their individual needs and preferences. This has led to a greater emphasis on the user experience and the ability to satisfy the particular needs and tastes of each consumer (Franke & Piller, 2004).

This paper studies the results of the creative process applied by novice designers to the design of a personalized object, taking results from different profiles of professional designer and prosumer/maker as examples. The objective is to contrast the common points of the process, and if the differences that are detected come from the personal profile, the design they intend or the tools they have at their disposal. Once analyzed, they are compared with the self-commission results carried out by novice designers whose creative process has been characterized from the proposal to the testing of a prototype and the formal definition.

The interest of this contribution lies in the orientation of the analyzed profiles, all of them with particular needs, towards their specific solution, with their own or customized design, but with similar

processes. With the new forms of digital manufacturing, using manufacturing and prototyping tools, DIY or Do It Yourself (DIY), the professional and novice designer have greater autonomy to develop their creativity and experiment creating their designs, validating their ideas and solving their particular needs (Gershenfeld, 2005).

Methodology

It has been intended to examine the possible relationship between self-commissioning and the concept of prosumer through bibliographic research and a search for examples of self-commissioning. Our objective is to determine whether the creative processes undertaken by designers in a self-order are similar to those undertaken by prosumers.

Examples openly published by Professional Designers (PD) and PROsumers (PR) have been used in order to illustrate and enrich the knowledge of design students or Novice Designers (ND), dealing with similar products and within the same sector of activity, as can be seen in Table 1. However, an effort has been made to promote freedom in the creative process of novice designers, both in the selection of the object to be designed and in the development of the process itself, including the different phases, methods and techniques used. Through this approach, autonomy and originality are promoted in the creative process of NDs, encouraging them to seek innovative solutions.

The initial investigation relates self-commissioning in the field of design, whether academic or not, with the intuitive creative process, the manufacture or materialization of the object to be designed. The cases will serve to document and

compare the common elements and differences. The cases of professionals and prosumers will be used as an example to compare the results of the profile of novice designers.

Of the professional designers, the products made as self-order are analyzed, the results they pursue and that they contribute to their profession, these cases have been extracted from online design magazines such as Core77, DesignBoom, Yanko Design, Experimenta, etc. For the prosumer profile, their results published on the net are sought on websites such as Instructables, Makezine, Thingiverse, Hackaday, Craftsby, among others, showing what types of objects or designs they make, what goals they pursue, their methods, and the results obtained.

In the case of a new designer, the results of an experience with 74 second-year students of a degree in Industrial Design Engineering and Product Development are used, in the subject Design Workshop III, Creativity, with 74 students, and carrying out a project called the Prosumer Project, their academic work will be studied as if it were a self-commission, the process developed, the personal and academic objectives and the final results. Students are taught the definition of prosumer and the meaning of self-entrustment (Asión-Suñer, 2021).

Figure 1 shows the model proposed for NDs. The self-order is the identification of an individual and specific need within your home environment, with the aim of designing a product that solves said problem. Emphasis is placed on the importance of each ND identifying their personal problem, thus highlighting their ability to detect their own needs and solve them autonomously through the prosumer

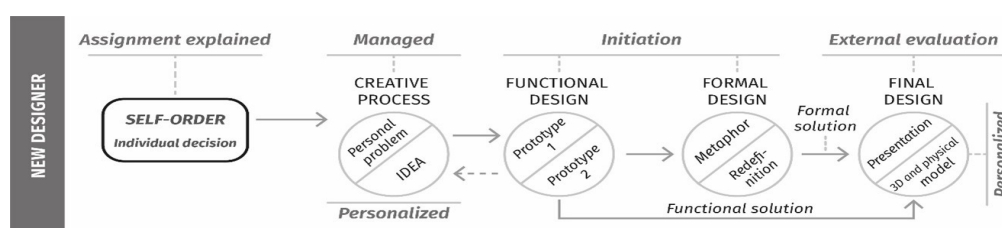


Figure 1.. Model shown to the new or novice designers (ND), to carry out their creative process of self-commissioning (Own elaboration).

Table 1. self-commissioning products for Professional Designers (PD) and Prosumers (PR). Source: own elaboration

	Diseñador/Estudio	Producto	Sector
DP	Nienke Hoogvliet (2023)	Material textil Fish Leather (Studio Nienke Hoogvliet, 2017)	Textil/mobiliario
	Agote Surfboards Triangle Studio (TRIANGLE-STUDIO, 2023)	Tablas de surf a medida Try Angle Paper (Eyeondesign, 2015).	Ocio y deporte Diseño gráfico
PR	Engineer42 (2023) Memestra (2022) Varios diseñadores	Sensor de CO2 Tabla de surf artesanal Camisetas personalizadas	Electrónica Ocio y deporte Diseño gráfico

design approach. They are instructed to adopt the role of the ideal prosumer, being designers, producers and consumers; assuming the responsibility of creating and manufacturing most of its product, thus avoiding the need to acquire it from third parties.

The creative process is initially led by asking them to document their problem through photographs and videos that show the context in which the problem occurs. From this point on, each ND decides in an intuitive and personalised way how to tackle the resolution of the problem. In the ideation phase each ND approaches solutions by experimenting with rapid prototypes to validate their first ideas. The project involves the creation of a functional prototype that demonstrates the resolution of the problem and the development of an aesthetic defined by means of a metaphor obtained through the analysis of an audiovisual in which they find attributes with which to dress the functional prototype. The requirements for the students are simple: at least one piece of the product must be designed and manufactured by the students themselves using manual and/or digital fabrication technologies, and they are encouraged to use recycled materials from their own home environment as far as possible. The results of the first prototype and the first tests should be used to improve the design, functionality, usability, ergonomics and sizing of the object or selection of materials (López-Forniés, 2021).

This methodology encourages independence and individual creativity, allowing students to become active agents in solving their own problems, while applying the principles of design and digital fabrication.

Models of creative self-commissioning processes

Table 1 presents 6 examples of design by professional and prosumer designers, used as a reference for students as an example and as a reference for comparative analysis. These cases have been chosen because they represent a functionally complex product (design of materials and electronics) with a very elaborate development process, a product in a single piece, even if it is constructed with different materials, related to leisure, sport and hobbies (surfboards) and an example of graphic design (experimental for the prosumer and home consumer of t-shirts).

Nienke Hoogvliet's (2017) research with seaweed has resulted in a cotton-like textile material with better yields and more sustainable by reusing fishing nets or similar. Another of her research has resulted in a new process for tanning leather from fish skins. Both his creative and design process is highly intuitive and his achievements derive from small breakthroughs in his experimentation. The aesthetics of his designs are "delicately crafted and the presentation is striking" (Hoogvliet, 2023).

The case of surfboard designers and craftsmen, such as Agote Surfboards (Basque Country Surf Company, 2023) or Surferrule (2023) is interesting, as they cover the three themes discussed in this paper: self-commissioning, prosumer and customisation. In addition, they state that they spend their periods without commissions developing their ideas to validate their designs, which they can then leave to test and/or sell. Nacho Agote, known as the luthier of the sea, has a work philosophy that transcends beyond the

dimension of the object. His boards have a higher value than the practice of surfing. His work is very vocational, with very few units per year and high dedication and care.

At a South Korean studio, the designers have supplemented their modest portfolio with a quarterly publication cleverly titled *Try Angle Paper* (Eyeondesign, 2015). The self-commissioned project gives them an opportunity to do things they might not be able to do for clients, such as experimenting with typography, making their own paper and creating products to sell online. The studio also uses self-commissioning as a free promotional tool for its work and compensates for its time.

In the group of prosumer, maker and DIY enthusiasts according to the Instructables website (Autodesk, 2023) there are 5 main groups of products for self-ordering: products that introduce small electronics, products for the home, handmade products, products for the outdoors (garden, terrace, etc.) and recipes. On the Makezine website (Make Community LLC, 2023) they have 8 categories where we find the following differences, digital fabrication, drones, vehicles, science and technology, workshop projects. On the Thingiverse community website they are grouped into nine categories with the following differences: hobbies, learning, tools, arts, accessories, games and toys. Other sites such as hackster.io (Avnet Inc., 2023) classify projects by difficulty, initial knowledge before self-ordering.

The first example is the experimentation with electronic components in which a CO2 sensor is designed (Engineer42, 2023) which has become a standard by COVID-19. With the motto “design your own CO2 sensor”, the project explains the entire implementation, from component list and assembly to adjustment. If you continue your search on the Instructables website, you will see that there are similar projects that show their own characteristics in the display of information with LEDs, LED strips or graphic displays, where each one requires different programming and therefore involves learning and advancing

the knowledge of the prosumer who is generating his prototype. In this type of project, the final finish, formal design and presentation are not the most important thing and sometimes detract from the functional value of the prototype.

The second example is about a designer of wooden surfboards (Memestra, 2022) which he makes by hand and which he displays on the web in an open way so that anyone who wants to can make their own board in their workshop or garage. In his design, which he has personalised by learning from other designers, he includes improvements tailored to his needs and shares all the information so that others can enjoy building their own board, achieving an autotelic experience in which the pleasure of building is shared with the enjoyment of the sport. It should be noted that this designer's experience and knowledge are high or expert level and his materials and manufacturing tools are of a quasi-professional standard. The finishes are professional, although handcrafted details are noticeable.

The third example is T-shirt designers who brand themselves using various technologies. This is not a specific designer, but a group of amateurs who make their own creations and share them by showing the design and execution process. The diversity of creative options is unlimited as it depends on the personal taste of the person designing. It also depends on the technique they execute or ask a company to execute for them. Many examples show the limitations of home-made techniques versus professional screen or transfer printing.

Figure 2 shows these processes and the different phases in which self-engagement, intuition and personalisation are manifested. For the professional designer, self-engagement is evident from the beginning of the creative process, at the moment the designer assumes responsibility for solving a personal need or problem. This approach implies a high degree of autonomy and reflection, as each designer is confronted with his or her own individual experience

and requirements, thus avoiding the universalisation of design and allowing for a personalised solution.

Intuitive thinking manifests itself for the professional in the creative phase and is based on his or her own knowledge as if working on a black box project. Personalisation manifests itself in the final stages of the creative process. However, this personalisation is latent from the beginning of the project, is deliberately pursued by the professional designer, represents the image of his target, and adapted by the prosumer, must be tailored to his specific needs and requirements. Personalisation becomes a way to ensure the relevance and attractiveness of the final product for consumers.

For the prosumer, self-consciousness emerges after a series of attempts and then intuitive thinking is applied throughout the process, from the cyclical phase of iterations in which the problem is analysed and fed back through ideas ranging from observation to discovery. Once an idea is reached and validated through prototyping, or editing, an improvement process is established leading to formal design and finalisation of the product that acquires personal emotional value.

The ND have been shown, in addition to these, other examples, always within a closer and more domestic environment, with different degrees of difficulty in the definition, development, construction and finishing.

Results

Table 2 displays the results of the search phase for PD and RP cases and examples, and those of the analysis of the ND projects; the main factors affecting self-commissioning, the type of creative process and the results obtained. With regard to motivations, those that produce benefits for oneself such as self-evaluation, self-fulfillment, autotelic experience, personal branding, autonomy, etc. predominate.

Self-engagement has the potential to lead to a design process because of the need for an autotelic experience, where the designer enjoys the very pleasure of doing what they are doing, not because they get a reward, but because they really enjoy what they are doing and are able to immerse themselves in a state of flow or Flow (Csikszentmihalyi, 1997).

The analysed cases of professional designers reflect varied motivations for self-commissioning (Walsh, 2019) and are divided into two groups. The first aims to personalise their image to present themselves to the outside world in a unique way. This will enable them to stand out from other professionals in their field. The second is to promote their products and ideas by showing their own style. Self-commissioned projects to promote their own ideas allow them to have more control over the creative process and to present products that reflect their personal vision, showing their ability to solve problems and create innovative solutions, experimenting

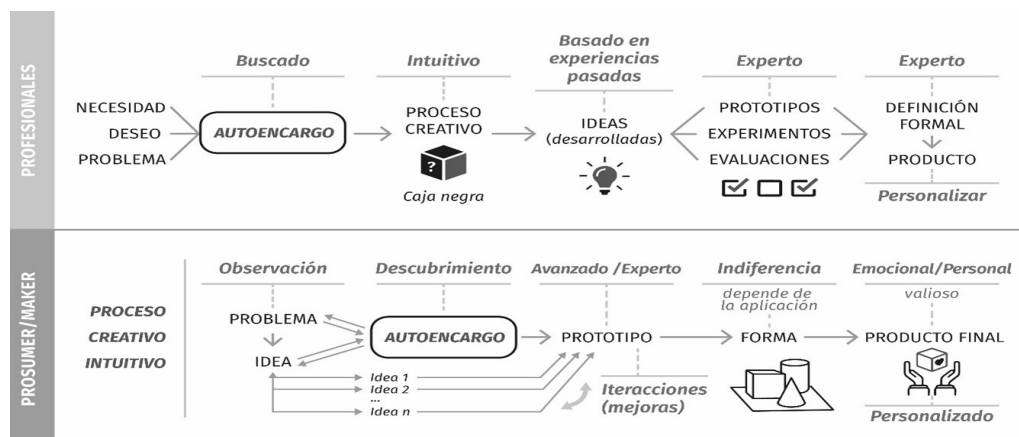


Figure 2. Self-commissioning creative process models for Professional Designer and Prosumer (own elaboration).

with new techniques and enhancing their reputation with clients or collaborators (Mineyama-Smithson, 2023). It can be said that the resolution of initial situations, ideas and solutions are solved with experience and according to an intuitive process based on experimentation, prototyping and successive evaluations for the improvement of the first ideas. Regarding the formal finishes and details of the final design, they are careful and valuable as they represent their own image, their personal touch and promotion to the outside world. The creative process is experimental, although previous knowledge has a great weight in the decisions.

With regard to the prosumer or maker group, it can be observed that self-commissioning appears for two reasons: either because of the detection of a problem or a need or because of an intuitive idea, we can say that self-commissioning comes from a discovery. The creative process is intuitive, based on a series of trial-and-error attempts that take you to a level of advanced prototyping (if you need to learn something specific) or expert if you master the field in which you are designing. Regarding the shape of the objects, this is something that is relegated to second place except in cases where the products are visible to third parties; this aspect seems indifferent and they feel comfortable with craft-type finishes and also feel that it is something

they can redo and improve at a later stage. The value of the designed object lies in the emotional value, in the satisfaction of a need not covered in any other way, a tailor-made adaptation or the overcoming of a personal challenge.

As a prosumer, the autotelic experience can provide personal fulfillment and satisfaction. By being involved in the entire design and production process, from the conception of the idea to the realisation of the final object, the prosumer can feel a unique connection to his or her work and to his or her ability to create. This can be especially rewarding when the designed object has a high level of complexity or requires specialised skills and knowledge to realise it (Csikszentmihalyi, 1997). Through personal fabrication, the prosumer creates his or her own objects using traditional hand tools and techniques, such as carpentry, blacksmithing, sewing or ceramics (Mota, 2011). On the other hand, digital fabrication involves the use of digital technologies, such as 3D printers, laser cutters and CNC machines, to produce objects. This offers prosumers the ability to create complex and detailed objects more quickly and accurately, which can increase their efficiency and creativity (Yoo et al., 2016).

In the group of novice designers, self-commissioning is something imposed and directed so that they can learn this concept

Tabla 2. Self-commissioning factors. Initiation, process and outcome.

Factor	Detonante o necesidad inicial (Autoencargo)	Proceso Creativo	Resultados obtenidos
DP	Dar la oportunidad a algo vanguardista, divertido o que apasione. Nutrir el alma creativa Mejorar las relaciones comerciales. Conexión emocional Autoevaluación. Valorar competencias y descubrir fortalezas personales Autorrealización y ambición personal. Expansión en RRSS Comercializar a través de productores de diseño Diseño experimental (Hoogvliet, 2023) Experiencia Autotélica. Disfrutar de tiempo no productivo Cambiar orientación profesional (Disrupt Design LLC, 2023)	Intuitivo y en caja negra Experimental Diversión Basado en experiencias previas	Depurados y alta calidad en los acabados Tarjeta de presentación
PR	Experiencia Autotélica Resolver una necesidad personal insatisfecha Aprendizaje autónomo. Aprender una determinada materia Fabricación personal y fabricación digital Compartir. Sentimiento de comunidad	Intuitivo en todo el proceso, incluso tras finalizar Copia y transformación de ejemplos Iterativo. Prueba y error	Poco cuidados en los detalles cuando es para autoconsumo Es más importante el vínculo afectivo
DN	Creación de un portfolio Formación como diseñadores (Walden & Kokotovich, 2012) Conocer una materia específica relacionada con diseño (Walden & Kokotovich, 2012) Crear su propia marca personal Autonomía en su proceso creativo y de diseño Emprendimiento (Universidad Politécnica de Valencia, 2023)	Muy diverso, sin patrón Tensión en la toma de decisiones Problemas mal definidos Los que experimentan resuelven mejor	Muy básicos y descuidados No hay preocupación por el detalle Es suficiente con que funcione medianamente bien No tiene el mismo valor que para el profesional

(although some already know it). They are given the option of choosing the problem, every day and personal, so that they can understand the concept of prosumer. Their creative process is directed and guided, although open, they learn to work with problems by analysing the causes and to delve deeper into the conditioning factors of design, by recording them with photographs and videos.

Table 3. Results of the designed objects classified by field of application. Source: own elaboration

Ámbito	Objeto
Almacenamiento y organización	Expositor bisutería. Organizador camisetas. Organizador de bolso. Organizador material ilustración. Organizador objetos personales. Organizador prendas para armario. Tendedor (de interior, de radiador y plegable)
Aseo e higiene personal	Estuche lentillas. Estuche limpiador férula dental. Estuche maquillaje. Quita-pelos para cepillo
Baño	Cierre cortinas de ducha. Filtro de pelos para ducha. No mojarse las mangas en el lavabo
Bricolaje	Cubierta cortacésped
Complementos	Empuñadura-funda de paraguas. Extensión paraguas para dos. Funda de móvil con alojamiento para tarjetas. Inmovilizador interior inflable para maletas. Llavero protector puertas
Deportes	Enrollador vendas boxeo
Electrónica	Organizador cables de ordenador. Bandeja móvil y pertenencias. Fundar portátil. Lámpara despertador para móvil. Soporte mandos a distancia. Soporte mandos consola. Soporte ordenador portátil. Soporte ratón sobre portátil. Soporte tableta
Limpieza hogar	Cuencos limpieza. Recogedor y cepillo para escoba
Menaje	Asa para transporte de pesos. Clasificador residuos domésticos. Compactador de latas. Contenedor hermético con válvula de vacío. Dosificador de cereales. Emparejador de calcetines para lavadora. Especiero múltiple. Faja antigoteo para tazas. Funda protectora de sandwichera. Lavavajillas. Organizador de especias. Organizador hilos de costura. Organizador de útiles de cocina. Pelador fruta. Pinza para platos calientes. Soporte cuchara para tazas
Mobiliario	Apoyo pies para sillas altas. Colgador paraguas. Dispositivo antivuelco silla oficina. Lámpara orientable. Mesita auxiliar cama. Soporte de secador de pelo. Soporte despertador. Soporte partituras. Superficie multifuncional para lavabo. Trinquete o freno para persiana
Motor	Funda casco para mochilas. Soporte calentador taza para coches
Ropa	Cordón cierre cremalleras de espalda. Percha (de viaje troquelada. extensible. para tendedor). Tacón plegable
Textil hogar	Cojín protege gafas

The students started with a process of detecting everyday problems to be solved, mainly using their own techniques based on Shadowing or the User's journey (Interaction

Design Foundation, 2023). They created a table that reviews the daily actions that they find annoying during the week at different times or in different spaces and that they would like to eliminate. The examples seen and the review of their daily lives allow them to decide which product to design, although this is the most critical point for them as they are forced to decide.

Their personal motivations are linked to their portfolio or future presentation letter, knowledge of a specific subject, doing a project related to their hobbies or creating a personal brand, being similar to those of the PDs and PRs. Academic motivations include training as designers and gaining autonomy in their creative process. Finally, there is a somewhat remote motivation to take the idea to production and turn their project into a company through entrepreneurship (Universidad Politécnica de Valencia, 2023) which could be related to the commercialisation of objects through PD or PR entrepreneurship.

Idea generation is also driven by the initial prototyping which forces them to self-evaluate. The first prototype is initiatory, in many cases it is the first time they make a working model, unlike the PDs and PRs who work immediately with prototypes and have to be insisted upon to realise and exploit them. However, it helps them to redefine the problem and iterate on ideas to improve until they reach the second prototype that will lead them to the solution, as a PR would do. For formal development, it is recommended to work with metaphors and the redefinition of concepts observed in other fields. Their final design is evaluated externally, by supervisors or teachers, which for them is a measure of the achievement of their design, unlike PDs and PRs who do self-evaluation.

In the case of novice designers, 74 self-commissioning cases were studied, in a small project called prosumer. In the selection of the object to be designed, 13 areas of domestic or everyday applications were found, see Table 3, there are repeated proposals in some groups. The diversity of products is very high, with interesting

and novel applications such as a manual dishwasher or a folding heel adaptable to flat shoes, and other very basic and essential ones such as organisation and tidying in the bedroom.

To highlight the problem, they photographed the actual situation of use that bothers them and described the reasons and constraints that cause the problem. Figure 3 shows the sequence made as a sequence of use like a storyboard. The description of the problem is completed by means of a series of questions similar to the creative techniques of 5W-H, the why of things, etc. (Neuronilla Creatividad Integral, 2023). In this way the problem is completely defined in its context, with the design factors and variables that condition it.



Figure 3. Example of problem definition (author: Matthis Bellanger)

The process continues with an individual and free generation of ideas, through textual or graphical techniques. It is recommended that they use both to start visualising the solution through images. The main techniques used are micro-drawings to get sketches and variations quickly and morphing using the pictures they have taken (Neuronilla Creatividad Integral, 2023).

Once the ideas are defined, they develop a prototype to explore functionality and feasibility. The prototypes are made with recycled materials so that they can be edited and changes can be made based on observations. The result is a dimensional approximation of the object and the type of materials needed for the prototype to be validated. The first tests allow improvements in terms of use, functionality, materials and structure, ergonomics, etc.

With regard to prototypes, 17% have not modified the initial prototype, 60% have made a prototype including variations or improvements and 23% have made several prototypes in which they proposed changes. 73% stated that the changes helped them to improve the design and 9% led them to change the initial design or concept. In this aspect, prototypes bring them closer to an experimental and trial-and-error process similar to professional designers and prosumers that allows them to improve their designs, and corresponds to the results of finishes and functional definition. In the evaluation of prototypes as useful for the creative process, 27% of respondents rated them as very useful and 56% stated that they were useful, none stated that they were not useful and only 17% stated that they were of little or no use or did not know what to answer. The data are taken from the Teaching Innovation project “Monitoring and improvement of the use of prototyping as a tool for learning the design process in the first courses of the Degree in Industrial Design Engineering and Product Development” PIIDUZ_2 Consolidated 916_2022 (Sierra-Pérez, 2022).

Only 30% of students used digital fabrication tools to make their prototypes. Handcrafted items work worse and look more fragile, which can be seen in the quality of their manufacturing and finishes. Those made with FabLab tools result in better finishes and functional improvements due to more testing. Prosumers use iterative processes to improve their prototypes by editing and improving them.



Figure 4. Images of the second prototype and its use (author: Matthis Bellanger)

The second prototype makes it possible to evaluate the design and introduce the necessary improvements. It also demonstrates the operation by means of a sequence of use with photographs and videos. Figure 4 shows the second prototype made with featherboard, on which some changes have been implemented and the functioning has been verified. It can be seen that the finish is made with modelling paste. The object has a non-definitive finish and needs to evolve in terms of finishes.

For formal design they work with two techniques: metaphor and redefinition. The technique of metaphor (Lubart & Getz, 1997) involves comparing two seemingly unrelated things in order to find similarities or patterns that allow a better understanding of the subject matter. These techniques are used in many creative fields, including design, advertising, literature and poetry.

Metaphor allows them to find an element linked to their functional object and through redefinition they will be able to endow their prototype with formal attributes and an aesthetic of its own. In the redefinition, the designer must take a short audio-visual defined by their metaphor and from this extract elements such as rhythm, colour, shapes, music, to assign them as attributes in their formal definition. Finally, they make a presentation of their final design by means of a 3D representation, digital or with a physical model, and renders or photographs. In the final solution, the functional and the formal definition must coexist in harmony. Therefore, the dimensions of the prototype and the proportions of the final object must be in unison.

The formal results, aesthetics, finishes and details are poor and undeveloped, similar to a RP, and unlike a PD, the previous experience of PDs and PDs is the differentiating element with respect to PDs. Only those NDs who have evolved and perfected their prototypes in the experimentation phase have achieved successful formal results. The level of difficulty and complexity of the object also influences, as a dishwasher is not comparable to an umbrella stand.

Conclusions

The differences between company commissioning and personal self-commissioning are clear. The former involves risks and responsibilities while the latter is a decision to satisfy a personal need or desire, not covered in the same way. Self-commissioning assumes risks as one's own and with low impact.

All three groups end up consuming their self-commissioned products, each with different objectives. Therefore, self-commissioning is a way of becoming a prosumer, establishing their own creative process, which can be more or less intuitive depending on each profile's experience. For the ND, the freedom of this process allows them to explore their creative intuition and respond to individual needs in a personalised way. This is following a prosumer-like approach even if they are unaware of it. The lack of experience makes this creative freedom stressful for the ND by not having an easy path to follow.

By fostering the connection between self-commissioning and prosumer character, it opens a path towards understanding intuitive creative processes driven by individual needs and exploring new possibilities in design.

Many designs considered good design (Erlhoff et al., 2008) are an elegant materialisation of the learning that designers have acquired through the continuous process of trial and error derived from their intuitions and the skills they experiment with the alternative solutions generated.

Prosumers feel satisfied with their functional results regardless of their formal appearance. They gain confidence to make new projects and emotionally bond with these objects (Chapman, 2015). The professional designer has a studio or workshop in which to recreate these sensations. It is imperative that the ND in a guided or voluntary way experiment with this type of project so that their creative and design processes improve, and their intuitive thinking grows.

Personalisation becomes a necessary act to satisfy the individual needs and specific preferences of each client (Asión-Suñer & López-Forniés, 2021). However, self-commissioning often involves customisation. All profiles have developed their objects with a high degree of customisation, which is a characteristic feature of the maker or prosumer sphere.

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Friction as a means of choice

ORIGINAL VERSION / VERSIÓN ORIGINAL

The wish to change something is a fundamental human characteristic. People strive, for example, to spend more time with their loved ones, engage in physical activity, eliminate bad habits such as excessive consumption of sweets or alcohol, or do good for the environment. This drive is interrelated with individuals' self-actualization, progress, adaptability, or the capability to adapt to new circumstances.

One way to change is to change everyday choices and practices. For example, in the evening, one is faced with the choice of giving in to a craving for something sweet like chocolate (just thinking about it makes me crave chocolate) or acting rationally and choosing an apple (because, as everyone knows, "An apple a day keeps the doctor away"). This conflict

between immediate gratification through chocolate and choosing an apple for long-term health, which represents an abstract, future-oriented, and rather uncertain state poses a challenge. In this dilemma between immediate pleasant gratification and future abstract goals (see also discounting, e.g., Samuelson, 1937), lies one of the challenges in making changes.

And as if it wasn't exhausting enough, this challenge is accompanied by another difficulty – the fight between two systems – in psychological theory they are defined as two-system models. Hofmann et al. (2009) explain that these models assume two structurally different information processing systems: a reflective system that makes slow decisions using many cognitive resources and an impulsive system that uses learned and often repeated behavioral routines. Resisting an impulse (such as consuming chocolate) and consciously choosing an apple instead (a reflective choice) requires self-control, which is, unfortunately, a limited resource that gradually depletes with frequent use. At the end of the day (quite literally), impulses win the battle for our behavioral control, and we find ourselves, for example, on the couch with a chocolate bar. Thus, change largely involves resisting the many immediate temptations (i.e., impulses) in favor of long-term abstract goals, which is challenging when the resource for resistance, namely self-control, is limited.

In this challenging struggle, some external support can help people pursue their future abstract goals in the long term.

In HCI, a dominant strategy for behavior change through interactive technologies is using appeals (also see *Persuasive Technology* by, e.g., B.J. Fogg [2003]). Appeals are rhetorical approaches based on the widespread belief that change is based on insight. For example, sports trackers or smart electricity meters inform individuals about inadequate physical activity or high power consumption. Although they are interactive technologies (in the form of a smartwatch or smart home appliance), they are merely personalized appeals that

do not influence impulsive behavior. They can never prompt a person to change their behavior in a specific situation, such as taking the stairs instead of the elevator (e.g., beneficial for daily step count) or taking shorter showers (e.g., beneficial for saving electricity in everyday life). Appeals assume that individuals may not know that chocolate is not ideal to achieve their goal of eating healthier or losing weight and that this is why they consume a chocolate bar in the evening. It becomes clear that this assumption may not be entirely true. Even when individuals know that they should take the stairs more often, that chocolate is unhealthy, and that they should consume less electricity, integrating these changes into daily life is challenging. Rhetorical appeals appear to be too weak in this regard. Instead of appeals, what is needed are effective alternative routines that can be implemented in daily life. The question then is, how to disrupt old routines and implement new goal-directed routines in everyday life?

Another approach in HCI, known as situational interventions, offers many advantages in this regard. They aim to change behavior by disrupting routines and presenting alternative courses of action in specific situations. Situated interventions can change the context and materialize behavior, for example, through nudging [Thaler & Sunstein, 2008]. By offering behavioral alternatives, situated interventions question established behaviors and ultimately break routines. However, such interventions that interrupt actions come with resistance from individuals.

In contrast to neutral and informative appeals, interventions take an active stance. One specific approach for such situational interventions, we introduced in HCI, is the Aesthetics of Friction (AoF) [Hassenzahl & Laschke, 2014]. The products of such an AoF are called “Pleasurable Troublemakers” (see both boxes on Keymoment and ReMind). The AoF is an approach to designing interactive technologies for behavior change. Such an AoF must consider two aspects: the friction itself and its acceptance.

Creating friction to instill change

As interactive objects, Pleasurable Troublemakers interrupt unreflective routines in specific situations where providing goal-directed behavior and a moment of reflection seems particularly appropriate. A crucial moment in this process is the interruption, which should occur when a choice has been made and can still be changed. Keymoment [Laschke et al., 2014], for example, is deliberately placed as a key rack in the hallway, as this is the place where mobility decisions can be made, considered, and still changed. ReMind [Laschke et al., 2013] is part of the home, providing the opportunity to consider and choose possible activities. Troublemakers are thus highly context-dependent, concrete, and present in moments where choices can still be changed. Moreover, both objects are tangible. While Pleasurable Troublemakers do not have to be tangible objects, there is an immense potential that comes from their tangibility. For instance, ReMind and Keymoment cause objects to fall (the bike key or pucks with goals) to change the users' context. As a result, they inevitably insist, much like Peter-Paul Verbeek's example of a speed bump that shakes the car and the driver, making it immediately apparent that one has been going too fast [Verbeek, 2006]. The resulting friction highlights unconscious, "unwanted" behavior, and the alternative shows a way out of it. The Troublemaker becomes a sort of materialized "implementation intention" [Gollwitzer, 1999] – a simple plan for "better" behavior. However, friction can also evoke negative feelings and even reactance [Brehm, 1966] if not adequately designed.

Easing friction through understanding

Therefore, Troublemakers need to be understanding. They must allow for the conscious disregard of suggested behavior. Perhaps one wanted to make a big grocery shopping trip in the suburbs, or it was pouring rain. There are many valid and less valid reasons to disregard the suggestion of Troublemakers, and Troublemakers should acknowledge it. Troublemakers should never force people to do something. They instead suggest options to choose from. Our approach aims to make decisions more conscious, getting people out of their routines and enabling them to make a more conscious yet situational decision, either in line with their routines or goals. They want to make change more likely but recognize that everyday choices are complex and come with many difficulties. From a design perspective, understanding and easing friction can take different forms. One way is to allow for cheating. Another way could be humor or irony (for both means, see ReMind and Keymoment). Both indicate that, in the end, what to eat or what mode of transportation to take remains the free choice of the individual, not the choice of Troublemakers. While Troublemakers actively facilitate certain changes, they also remain disinterested objects – also a way which might represent naivety and irony. They do not care about health or sustainability and are unaware of such considerations. Alternatives, naivety, humor, and understanding are supposed to make the friction bearable. They transform Troublemakers into what we call "Pleasurable Troublemakers."

Keymoment - A key rack that makes me think

Keymoment [Laschke et al., 2014] addresses the challenge of both contributing to the environment and promoting personal physical activity (Figure 1). The World Health Organization suggests integrating biking into everyday life, for example, on the way to work, to achieve these goals [World Health Organization, 2010]. However, implementing this goal is easier said than done. Keymoment materializes a simple plan to implement this goal. It is a key rack placed in a common place, such as in the hallway or near the front door. It holds the bike key and the car key side by side. This way, Keymoment confronts people with the choice between biking and driving. Taking the bike key, one chooses the alternative that leads to the “desired” goal. However, if one consciously or unconsciously chooses the car key, the bike key falls to the ground, which most people pick up. With both keys in hand, one faces a real dilemma: take the bike or stick with the car. This way, Keymoment breaks the routine of grabbing the car key and encourages people to think. Moreover, Keymoment offers a goal-directed alternative in the form of the bike.

Still, dropping the bike key can be annoying. Finally, one wanted to go with the car, not the bike. While taking the car was initially an easy decision, one suddenly finds themselves in a situation where they must internally justify this choice. Keymoment asks individuals to make a thoughtful decision and presents them with a choice. This can cause friction. To make the friction created more bearable, Keymoment includes some design elements. For example, you can take a break by placing your bike key on the Keymoment (Figure 2). The ability to cheat the system is also part of its design (Figure 3).

Additionally, one can exchange the bike key with the car key, which causes Keymoment to suggest the car key, even if the person initially reached for the bike key. However,

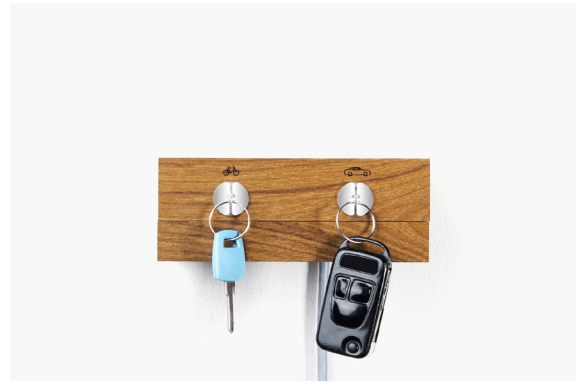


Figure 1. The Keymoment with a bike and car key side by side.



Figure 2. The bike key on top to pause the mechanism

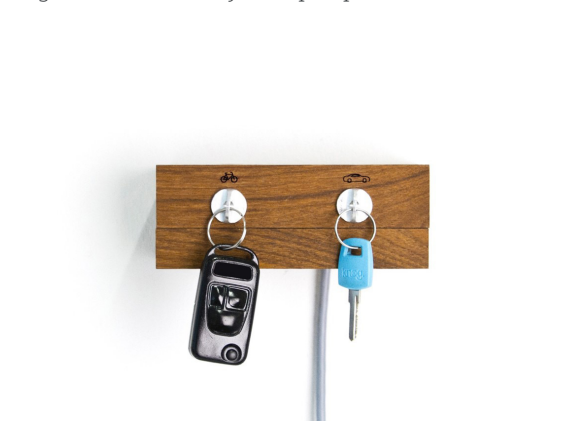


Figure 3. Changed keys enables cheating the system.

because it is difficult to cheat oneself, Keymoment creates an ironic moment – a moment that can be humorous and revealing at the same time. Other elements of understanding could also be considered. For example, Keymoment could pause dropping the bike key when it rains.



Figure 4. ReMind as part of the home.



Figure 5. Writing a goal on a puck.

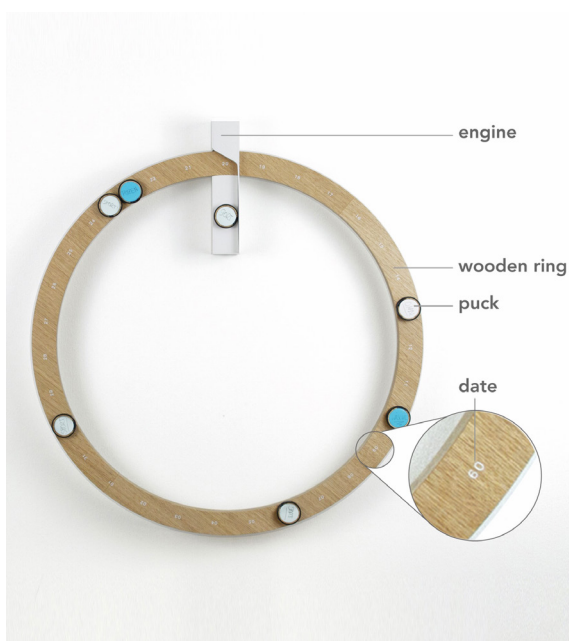


Figure 6. ReMind in its several parts.

ReMind - Get it done, postpone it, or sweep it under the carpet

ReMind [Laschke et al., 2013] is a Pleasurable Troublemaker designed to help people overcome procrastination and make them reflect (Figure 4). It is a wall-mounted hybrid of a calendar and a to-do list that constantly confronts its users with their self-set personal goals [Brechmann et al., 2013]. ReMind consists of a wooden ring (approximately 75 cm in diameter), a rectangular motor at the top, and ten magnetic pucks with Post-it notes (Figure 5). Each puck can be labeled with a personal goal. Since a key recommendation is to set a realistic number of personal goals, the number of pucks is deliberately limited to ten. This facilitates in-depth reflection on the selection of goals to be addressed next. The wooden ring has 31 sections (i.e., days), each with a number. Each section provides space for a single task to be planned for that day. ReMind also supports planning by limiting the period of planning to one month. More extended time periods encourage people to plan tasks very far into the future, which is not particularly helpful.

Over time, the ring rotates one section clockwise each day (for months with less than 31 days, these days are crossed out). At the top of the ring, the current day is always present (Figure 6). Additionally, at the top is a sort of barrier where unattended goals are stacked - just like in real life. When too many goals (i.e., pucks) gather at the barrier, they fall to the floor one by one. ReMind throws (to its user) undone goals on the floor. Picking up a puck from the ground becomes picking up a goal. An opportunity for choice is formed here: The user can complete the goal immediately, postpone it again by choosing a new date, or give up on it - by sweeping it under the carpet. By providing such a (tangible) choice, ReMind creates friction. This is intended to encourage users to think and act [Laschke et al., 2011].

Friction is necessary to bring about change but must be designed thoughtfully. To do this, we adopt three strategies from AoF:

naivety, understanding, and irony/ambiguity. For instance, ReMind is not particularly clever. It does not seem to offer elaborate algorithms to find solutions to the problem of procrastination. It's a to-do list, and its only power over its user is the almost pathetic ability to litter the floor with undone goals.

Moreover, ReMind does not create a choice that requires some superhuman powers to behave perfectly. Furthermore, ReMind allows for cheating by design. It is as easy as pushing a goal over the barrier and putting it off for another 31 days; or sweeping the puck on the floor under the carpet (i.e., out of sight, out of mind). In a sense, ReMind itself embodies procrastination by providing a 31-day time frame. By allowing the very same lapses that it wants to help overcome, ReMind shows some understanding of the complexity of the problem. ReMind becomes a "partner in crime," a mirror of the self. It is easy to cheat ReMind but challenging to cheat oneself.

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VERSIÓN TRADUCIDA

El deseo de cambiar algunas cosas es una característica fundamental del ser humano. Las personas se esfuerzan, por ejemplo, por pasar más tiempo con sus seres queridos, practicar actividad física, eliminar malos hábitos como el consumo excesivo de dulces o alcohol, o hacer algo bueno por el medio ambiente. Esta motivación está interrelacionada con la autorrealización de los individuos, el progreso, la adaptabilidad o la capacidad de adaptarse a nuevas circunstancias.

Una forma de cambiar es modificar las elecciones y prácticas diarias. Por ejemplo, por la noche, uno se enfrenta a la decisión de ceder ante el antojo de algo dulce como el chocolate (solo de pensarlo me provoca antojo de chocolate) o actuar racionalmente y elegir una manzana (porque, como todos saben, “una manzana al día mantiene al médico alejado”). Este conflicto entre la gratificación inmediata a través del chocolate y la elección de una manzana para la salud a largo plazo, que representa un estado abstracto, orientado hacia el futuro y bastante incierto, plantea un desafío. En este dilema entre la gratificación inmediata placentera y los objetivos abstractos futuros (ver también la reducción, por ejemplo, Samuelson, 1937), se encuentra uno de los desafíos para realizar cambios.

Y como si no fuera lo suficientemente agotador, este desafío viene acompañado de otra dificultad: la lucha entre dos sistemas, definidos en la teoría psicológica como modelos de dos sistemas. Hofmann et al. (2009) explican que estos modelos asumen dos sistemas de procesamiento de información estructuralmente diferentes: un sistema reflexivo que toma decisiones lentas utilizando muchos recursos cognitivos y un sistema impulsivo que utiliza rutinas de comportamiento aprendidas y a menudo repetidas. Resistir un impulso (como consumir chocolate) y elegir conscientemente una manzana en su lugar (una elección reflexiva) requiere autocontrol, que lamentablemente es un recurso

limitado que se agota gradualmente con su uso frecuente. Al final del día (literalmente hablando), los impulsos ganan la batalla por el control de nuestro comportamiento y nos encontramos, por ejemplo, en el sofá con una barra de chocolate. Por lo tanto, el cambio implica en gran medida resistir las muchas tentaciones inmediatas (es decir, impulsos) en favor de los objetivos abstractos a largo plazo, lo cual es desafiante cuando el recurso para la resistencia, es decir, el autocontrol, es limitado.

En esta lucha desafiante, cierto apoyo externo puede ayudar a las personas a perseguir sus objetivos abstractos futuros a largo plazo.

En la Interacción Persona-Computadora (IPC), una estrategia dominante para el cambio de comportamiento a través de tecnologías interactivas es utilizar enfoques persuasivos (también ver Tecnología Persuasiva, por ejemplo, de B.J. Fogg [2003]). Los enfoques persuasivos son aproximaciones retóricas basadas en la creencia generalizada de que el cambio se basa en la reflexión. Por ejemplo, los dispositivos para el seguimiento de actividades deportivas o los medidores inteligentes de electricidad informan a los individuos

Crear fricción para instaurar el cambio

Como objetos interactivos, los Pleasurable Troublemakers interrumpen rutinas automáticas en situaciones específicas donde proporcionar un comportamiento dirigido a objetivos y un momento de reflexión parece especialmente apropiado. Un momento crucial en este proceso es la interrupción, que debe ocurrir cuando se ha tomado una elección y aún se puede cambiar. Keymoment [Laschke et al., 2014], por ejemplo, se coloca deliberadamente como un colgador de llaves en el pasillo, ya que este es el lugar donde se pueden tomar decisiones de movilidad, considerarlas y aún cambiarlas. ReMind [Laschke et al., 2013] es

parte del hogar, brindando la oportunidad de considerar y elegir posibles actividades. Los Troublemakers son, por lo tanto, altamente dependientes del contexto, concretos y presentes en momentos en los que las elecciones aún se pueden cambiar. Además, ambos objetos son tangibles. Si bien los Pleasurable Troublemakers no tienen que ser necesariamente objetos tangibles, existe un inmenso potencial que proviene de su tangibilidad. Por ejemplo, ReMind y Keymoment hacen que los objetos caigan (la llave de la bicicleta o discos con objetivos) para cambiar el contexto del usuario. Como resultado, insisten inevitablemente, al igual que el ejemplo de Peter-Paul Verbeek de un resalto que sacude el automóvil y al conductor, haciendo evidente de inmediato que se ha estado yendo demasiado rápido [Verbeek, 2006]. La fricción resultante resalta comportamientos inconscientes y “indeseados”, y la alternativa muestra una salida de ellos. El Troublemaker se convierte en una especie de “intención de implementación” materializada [Gollwitzer, 1999], un plan simple para un comportamiento “mejor”. Sin embargo, la fricción también puede evocar sentimientos negativos e incluso reactancia [Brehm, 1966] si no se diseña adecuadamente.

Facilitando la fricción a través de la comprensión

Por lo tanto, los Troublemakers deben ser comprensivos. Deben permitir el desprecio consciente del comportamiento sugerido. Tal vez alguien quiera hacer una gran compra de comestibles en las afueras de la ciudad, o tal vez esté lloviendo a cántaros. Hay muchas razones válidas y menos válidas para ignorar la sugerencia de los Troublemakers, y los Troublemakers deben reconocerlo. Los Troublemakers nunca deben obligar a las personas a hacer algo. En cambio, sugieren opciones entre las cuales elegir. Nuestro enfoque busca hacer que las decisiones sean más conscientes, sacando a las personas de sus rutinas y permitiéndoles tomar decisiones más

conscientes y situacionales, ya sea en línea con sus rutinas o sus objetivos. Queremos aumentar la probabilidad de cambio, pero reconocemos que las elecciones diarias son complejas y conllevan muchas dificultades. Desde una perspectiva de diseño, comprender y facilitar la fricción puede adoptar diferentes formas. Una forma es permitir hacer trampa. Otra forma podría ser el humor o la ironía (para ambos casos, ver ReMind y Keymoment). Ambos indican que, al final, qué comer o qué modo de transporte tomar sigue siendo la elección libre del individuo, no la elección de los Troublemakers. Si bien los Troublemakers facilitan activamente ciertos cambios, también siguen siendo objetos desinteresados, lo cual puede representar ingenuidad e ironía. No les importa la salud ni la sostenibilidad y no son conscientes de esas consideraciones. Las alternativas, la ingenuidad, el humor y la comprensión pretenden hacer que la fricción sea tolerable. Transforman a los Troublemakers en lo que llamamos “Pleasurable Troublemakers”.

Keymoment: Un perchero de llaves que me hace reflexionar

Keymoment [Laschke et al., 2014] aborda el desafío de contribuir al medio ambiente y promover la actividad física personal (Figura 1). La Organización Mundial de la Salud sugiere integrar el uso de la bicicleta en la vida diaria, por ejemplo, en el trayecto al trabajo, para alcanzar estos objetivos [Organización Mundial de la Salud, 2010]. Sin embargo, implementar este objetivo es más fácil decirlo que hacerlo. Keymoment materializa un plan sencillo para poner en práctica este objetivo. Es un perchero de llaves colocado en un lugar común, como en el pasillo o cerca de la puerta de entrada. Sostiene la llave de la bicicleta y la llave del coche lado a lado. De esta manera, Keymoment confronta a las personas con la elección entre ir en bicicleta o en coche. Al tomar la llave de la bicicleta,

se elige la alternativa que conduce al objetivo “deseado”. Sin embargo, si se elige consciente o inconscientemente la llave del coche, la llave de la bicicleta cae al suelo, lo que la mayoría de las personas recoge. Con ambas llaves en la mano, uno se enfrenta a un verdadero dilema: tomar la bicicleta o seguir con el coche. De esta manera, Keymoment rompe la rutina de tomar la llave del coche y anima a las personas a reflexionar. Además, Keymoment ofrece una alternativa dirigida al objetivo en forma de la bicicleta.

Sin embargo, dejar caer la llave de la bicicleta puede resultar molesto. Al final, uno quería ir en coche, no en bicicleta. Aunque al principio tomar el coche fue una decisión fácil, de repente uno se encuentra en una situación en la que debe justificar internamente esa elección. Keymoment pide a las personas que tomen una decisión reflexiva y les presenta una opción. Esto puede generar fricción. Para hacer más llevadera la fricción creada, Keymoment incluye algunos elementos de diseño. Por ejemplo, se puede tomar un descanso colocando la llave de la bicicleta en el Keymoment (Figura 2). La posibilidad de engañar al sistema también forma parte de su diseño (Figura 3).

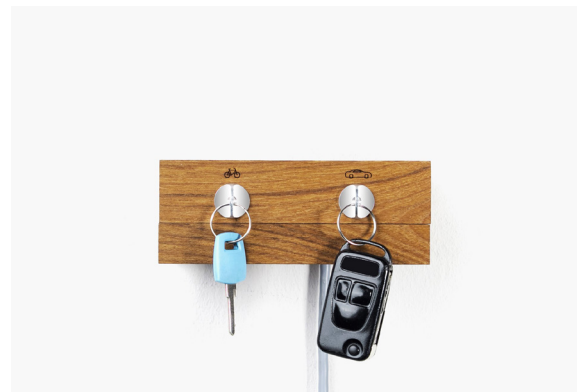


Figure 1. The Keymoment with a bike and car key side by side.



Figure 2. The bike key on top to pause the mechanism



Figure 3. Changed keys enables cheating the system.

Además, se puede intercambiar la llave de la bicicleta con la llave del coche, lo que hace que Keymoment sugiera la llave del coche, incluso si la persona inicialmente alcanzó la llave de la bicicleta. Sin embargo, debido a que es difícil engañarse a uno mismo, Keymoment crea un momento irónico, un momento que puede ser humorístico y revelador al mismo tiempo. También se podrían considerar otros elementos de comprensión. Por ejemplo, Keymoment podría suspender la caída de la llave de la bicicleta cuando llueve.

ReMind - Hazlo, posponlo o escóndelo bajo la alfombra

ReMind [Laschke et al., 2013] es un Pleasurable Troublemaker diseñado para ayudar a las personas a superar la procrastinación y hacerles reflexionar (ver figura 4). Es una combinación montada en la pared de un calendario y una lista de tareas pendientes que constantemente confronta a los usuarios con sus metas personales autoestablecidas [Brechmann et al., 2013]. ReMind consta de un anillo de madera (aproximadamente 75 cm de diámetro), un motor rectangular en la parte superior y diez fichas magnéticas con notas adhesivas (ver figura 5). Cada ficha se puede etiquetar con una meta personal. Dado que una recomendación clave es establecer un número realista de metas personales, el número de fichas está deliberadamente limitado a diez. Esto facilita una reflexión profunda sobre la selección de las metas que se abordarán a continuación. El anillo de madera tiene 31 secciones (es decir, días), cada una con un número. Cada sección proporciona espacio para planificar una sola tarea para ese día. ReMind también apoya la planificación al limitar el período de planificación a un mes. Los períodos de tiempo más largos animan a las personas a planificar tareas muy lejanas en el futuro, lo cual no es especialmente útil.

Con el tiempo, el anillo gira una sección en sentido horario cada día (para los meses con menos de 31 días, esos días se tachan). En la parte superior del anillo, el día actual está siempre presente (ver figura 6). Además, en la parte superior hay una especie de barrera donde se apilan las metas no atendidas, tal como ocurre en la vida real. Cuando muchas metas (es decir, fichas) se acumulan en la barrera, caen al suelo una por una. ReMind arroja (a su usuario) metas sin cumplir al suelo. Recoger una ficha del suelo implica recoger una meta. Aquí se crea una oportunidad de elección: el usuario puede completar la meta de inmediato, posponerla nuevamente eligiendo una nueva fecha o renunciar a ella al ocultarla bajo la alfombra. Al proporcionar una opción



Figure 4. ReMind as part of the home.



Figure 5. Writing a goal on a puck.

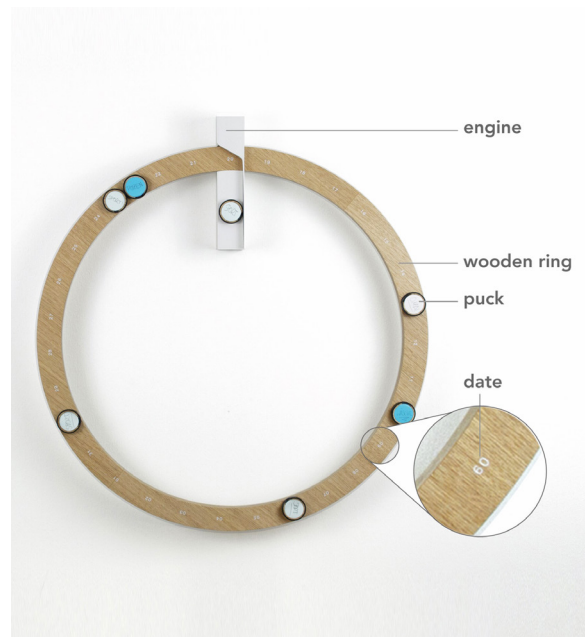


Figure 6. ReMind in its several parts.

(tangible) de este tipo, ReMind crea fricción. Esto tiene la intención de fomentar que los usuarios piensen y actúen [Laschke et al., 2011].

La fricción es necesaria para provocar el cambio, pero debe ser diseñada cuidadosamente. Para lograr esto, adoptamos tres estrategias del AoF: ingenuidad, comprensión e ironía/ambigüedad. Por ejemplo, ReMind no es particularmente astuto. No parece ofrecer algoritmos elaborados para encontrar soluciones al problema de la procrastinación. Es una lista de tareas, y su único poder sobre el usuario es la casi patética capacidad de llenar el suelo con metas sin cumplir.

Además, ReMind no crea una elección que requiera habilidades sobrehumanas para comportarse perfectamente. Además, ReMind permite hacer trampa por diseño. Es tan fácil como empujar una meta sobre la barrera y posponerla por otros 31 días; o esconder la ficha del suelo bajo la alfombra (es decir, fuera de la vista, fuera de la mente). En cierto sentido, ReMind encarna la procrastinación al proporcionar un marco de tiempo de 31 días. Al permitir las mismas fallas que intenta ayudar a superar, ReMind muestra cierta comprensión de la complejidad del problema. ReMind se convierte en un “compañero en el delito”, un espejo del yo. Es fácil engañar a ReMind pero difícil engañarse a uno mismo.

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Nuevos métodos y herramientas aplicados para la transferencia de conocimiento de los nanomateriales: Un reto de diseño para la empresa de Grupo Antolín | New methods and tools applied for the transfer of knowledge of nanomaterials: A design challenge for Grupo Antolin's company

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Resumen:

En todo proceso de diseño de producto, el diseñador debe tener en cuenta tanto los materiales como las tecnologías con los que debe trabajar. Actualmente, materiales y tecnologías se están convirtiendo en uno de los elementos principales para fomentar la innovación y agregar valor a los productos finales. Entre los múltiples materiales los nanomateriales presentan un especial interés. La nanotecnología está llamada a desempeñar un papel clave en todo el mundo en el siglo XXI, ya que se trata de una tecnología intersectorial, cada vez más relevante para ámbitos económicos como la química, la tecnología médica, la automoción o la industria alimentaria. ¿Pero, si el diseñador desconoce cómo se puede trabajar con él y quiere saber el alcance de este nuevo material? ¿Cómo transferir estos conocimientos, relacionados con los nanomateriales, de la teoría a la práctica? La industria demanda expertos (diseñadores) que puedan salvar la distancia entre el conocimiento teórico y las aplicaciones prácticas de los nanomateriales: productos, servicios y experiencias. Este artículo recoge un método de transmisión del conocimiento, en el que se pueden diferenciar dos tareas principales: 1) un componente educativo primario, en el que se divulgan, de una forma didáctica óptima, los conocimientos sobre los nuevos materiales y sus propiedades, y 2) un segundo componente

más práctico en el que la información se convierte en ideas prácticas, y en aplicaciones específicas aplicadas a un reto propuesto en colaboración con el grupo Antolín.

Palabras clave: Proceso de diseño; Educación en diseño; Diseño Industrial; Nuevos materiales; Nanomateriales; Transferencia de conocimiento; Workshop

Abstract:

In any product design process, the designer must take into account both the materials and technologies with which he/she must work. Currently, materials and technologies are becoming one of the main elements to foster innovation and add value to final products. Among the many materials, nanomaterials are of particular interest. Nanotechnology is set to play a key role worldwide in the 21st century, as it is a cross-sectoral technology, increasingly relevant to economic fields such as chemistry, medical technology, automotive or food industry. But, if the designer does not know how to work with it and wants to know the scope of this new material, how to transfer this knowledge, related to nanomaterials, from theory to practice? The industry demands experts (designers) who can bridge the gap between theoretical knowledge and practical applications of nanomaterials: products, services and experiences. This article presents a method of knowledge transmission, in which two main tasks can be distinguished: 1) a primary educational component, in which knowledge about new materials and their properties is disseminated in an optimal didactic way, and 2) a second more practical component in which the information is converted into practical ideas and specific applications applied to a challenge proposed in collaboration with the Antolin group.

Keywords: Design Process; Design Education; Industrial Design; New Materials; Nanomaterials; Knowledge Transfer; Workshop.

Introducción

La importancia de los materiales a lo largo de los siglos se refleja en cómo hablamos y reconocemos a las civilizaciones antiguas en función del material que se utilizó en esas épocas. Por eso las podemos reconocer como la edad de piedra, de bronce y la edad del hierro. Posteriormente, tras la revolución industrial, comienzan a aparecer nuevos materiales y nuevos procesos de transformación. Aparecen los polímeros, los biomateriales y los materiales compuestos, ... que dotan al producto de mejores prestaciones. En la actualidad se sigue investigando en nuevos materiales, materiales más sostenibles o materiales que debidamente modificados les otorgan nuevas propiedades. Podemos afirmar que los materiales juegan un rol muy importante en el diseño industrial ya que su objetivo es crear o re-diseñar productos con características estéticas y funcionales que resuelvan necesidades concretas de las personas y de la sociedad.

Una clave importante en el diseño y desarrollo de producto es, por tanto, la adecuada elección del material con que se debe trabajar para conseguir el mejor resultado. Pero ¿y si ese material es un material emergente con mejores características y que por lo tanto ofrece nuevas aplicaciones, nuevos diseños mejorados? Pero desconocemos cómo se puede trabajar con él y ¿cómo saber el alcance de estos nuevos materiales? Observamos cómo los avances que se producen en el desarrollo de estos materiales emergentes están brindando nuevas posibilidades a los diseñadores. Elegir el material adecuado para un determinado producto puede llegar a ser una tarea compleja siendo, a la vez, un factor fundamental para el éxito del producto. Los materiales y las tecnologías se están convirtiendo en uno de los elementos principales de la práctica del diseño de productos como palanca para fomentar la

innovación y agregar valor a los productos finales.

A menudo, cuando se piensa en estos nuevos materiales, o más bien en materiales innovadores, se les estudia desde un punto de vista exclusivamente relacionado con sus propiedades: tanto químicas, como físicas (masa, peso, volumen, densidad, resistividad eléctrica, conductividad térmica...), o mecánicas (comportamiento a tracción, compresión, rigidez, dureza, fragilidad, elasticidad...). Y se estudian ya sea en relación a la práctica industrial o en relación a diferentes asignaturas en el campo de la enseñanza. Por lo que estos materiales pueden revitalizar el diseño, crear nuevas oportunidades de negocio, transformar las actividades industriales, concebir soluciones más sostenibles, diseños más creativos.

Entonces... ¿Cómo diseñar con y para estos nuevos materiales? ¿Cómo conocer el alcance de los nuevos materiales? ¿Cómo se transmite el conocimiento que se desarrolla en los centros de investigación, en las universidades a las empresas? ¿Cómo concienciar a los diseñadores y brindarles la experiencia adecuada sobre cómo aprovechar esas enormes oportunidades que ofrecen los materiales avanzados? ¿Cómo ver que el diseño podrá desarrollar así todo su potencial como motor de innovación y competitividad europea?

Se puede constatar una brecha entre el diseño creativo y la investigación y desarrollo de nuevos materiales y tecnologías que se utilizarán en los nuevos productos. Y en el centro del problema se puede observar a escasez de colaboración entre investigadores y las industrias creativas.

En el marco de los materiales emergentes, los que hemos detectado que presentan un especial interés son los nanomateriales [P. Morer 2020]. La nanotecnología está llamada a desempeñar un papel clave en todo el mundo en el siglo XXI, ya que se trata de una tecnología intersectorial, cada vez más relevante para ámbitos económicos como la química, la tecnología médica, la automoción o la

industria alimentaria. Es un reto el hecho de que las industrias sepan cómo aplicar los nanomateriales y obtener nuevos productos industriales con propiedades mejoradas (antigrafiti, anticorrosión, ignífugos, antifúngicos, antifricción, antigrasa y aceites, antibacterianos, autolimpiantes, lubricantes secos, pulidores, aplicaciones fotocatalíticas, etc.).

La cuestión se centra en CÓMO transferir estos conocimientos, relacionados con los nanomateriales, de la teoría a la práctica. La industria demanda una necesidad creciente de expertos (diseñadores) que puedan salvar la distancia entre el conocimiento teórico y las aplicaciones prácticas de los nanomateriales para desarrollar nuevos productos, servicios y experiencias.

El presente artículo recoge las técnicas didácticas y creativas específicas utilizadas en un taller realizado en colaboración con el grupo Antolín, fabricante y proveedor de nanofibras helicoidales de carbono.

Metodología

Se ha visto cómo los materiales y tecnologías son tema de vital importancia en los planes de estudios de la Educación en Diseño. Esta área es conocida por necesitar actualizaciones continuas (Zhou et al., 2019). Están en continuo desarrollo. Los profesionales del diseño y los estudiantes necesitan adquirir continuamente conocimientos, habilidades y competencias, no solo para que sus diseños exploten las posibilidades de los materiales disponibles, sino también para contribuir a la innovación y el desarrollo de nuevos materiales (Haug, 2018). Hemos pasado de un enfoque de perfil “duro” -basado principalmente en la ciencia (Ashby et al., 2007) a un enfoque de perfil “suave”, donde se hace más hincapié en el enfoque didáctico de la enseñanza de los materiales (Rognoli et al., 2004; Rognoli, 2011; Karana, et al., 2010; Zuo, 2010; Van Kesteren, 2010; Karana et al. 2013), y en enfoques “guiados por el diseño” (Ashby et al., 2007) (Informe Myerson, 1991), enfoques desde la comprensión de las necesidades, la experimentación directa con los materiales,

la discusión con expertos. En este marco, métodos como el Active learning (Bonwell & Eison, 1991) y Experiential Learning (Kolb, 1984) son enfoques fundamentales de enseñanza y aprendizaje, que involucran a los estudiantes en un desafío de diseño con empresas (Piselli, et al. 2018) aprendiendo a través de la creación (Pedgley, 2010).

Se observa, asimismo, que desde las áreas de I+D se fomentan las metodologías basadas en la ejecución de diferentes talleres, en los que se llevan a cabo programas didáctico-creativos, diseñados específicamente para estimular la percepción creativa de los participantes. Resulta de especial interés encontrar “usos” ideales para los materiales emergentes y las tecnologías relacionadas (EMT) derivados de los avances en I+D en los ámbitos de la ciencia y la ingeniería de materiales.

Entre estos métodos de transmisión del conocimiento podemos diferenciar dos tareas principales: 1) por una parte, un componente educativo primario, en el que se divulgan, de una forma didáctica óptima, los conocimientos sobre los nuevos materiales y sus propiedades, y por otra, 2) en el que la información se convierte en ideas prácticas, adecuadas aplicaciones específicas. Mientras que la primera tarea se centra en la divulgación de datos fácticos, relativos a aspectos cuantitativos de naturaleza científica, el segundo paso es un medio más cualitativo y de inspiración intuitiva.

Ambas tareas se llevaron a cabo en el marco de un taller, en el que participaron un total de 25 estudiantes de cuatro universidades europeas (School of Design from Politecnico di Milano; School of

Chemical Technology from Aalto University; Material Design Lab from Copenhagen School of Design and Technology; School of Engineering from Universidad de Navarra-Tecnun) y empresas del sector. Durante el taller se les presentó un reto a resolver de la mano de una empresa líder como es el Grupo Antolín. Uno de los primeros pasos se centró en la divulgación de los distintos nanomateriales y sus propiedades. La información se transmitió de forma oral con un amplio glosario de apoyo sobre las terminologías específicas utilizadas para describir los fenómenos que cabe esperar que se produzcan en el sector de los nanomateriales y los procesos de fabricación. Dado que la mayor parte de la actividad de los nanomateriales no es perceptualmente evidente, sino de hecho imperceptible por los sentidos, los contenidos didácticos tratados en las conferencias se impartieron de una manera especializada que permitiera comprender su contenido a través de modelos teóricos explicativos apoyados por diversas formas de apoyo infográfico, impartidos en paralelo.

2.1. Cómo introducirse en los nanomateriales: Curso online

Previamente a la realización del taller in situ, se realizó un primer curso en formato on-line, en la que se introdujo a los estudiantes en los conceptos básicos y clave relacionados con los nanomateriales. Este curso para el aprendizaje se dividió en tres partes, como se muestra en la siguiente tabla 1:

Parte 1: Introducción. Esta parte se dividió en tres módulos:

Módulo 1: ¿Qué son los nanomateriales y la nanotecnología?

Tabla 1. Estructura del curso on-line

When	What	Who	Where
Parte 1: Introducción (1-2h) Vídeo presentación del objetivo de la actividad. Visualización de vídeos (7-10 min cada uno) (TED Talks, Youtube...) Cuestionarios de preguntas que puedan ayudar a los alumnos a aumentar su comprensión de los conceptos básicos.	Conceptos clave, charlas inspiradoras	Tutores	Online - link
Parte 2: Sesión de preguntas y respuestas y tareas Conversación o debate en grupos (máx. 1h). Debate con los supervisores y/o expertos sobre los vídeos y materiales de la Parte 1. Preparación de preguntas para los expertos	Debates en pequeños grupos para debatir y profundizar en los materiales, las tecnologías y los casos	Supervisor Tutores Expertos	Online - Meet
Parte 3: Collect feedback (max 20 min) Cuestionario online	Feedback de los estudiantes	Supervisor Tutores	Online - link

Se introdujeron conceptos como ¿qué es la nanotecnología? ¿Qué entendemos por pequeño? ¿Y cómo puede mejorar nuestras vidas? Y ver cómo la Nanotecnología explora la ciencia y la ingeniería de la materia a nano-escala. La nanotecnología implica manipular y controlar la materia de un nanómetro a 100. Asomarse a las múltiples aplicaciones de las nano-partículas en sectores tan diversos como la informática, la energía, el transporte, la sanidad o la protección del medio ambiente.

Módulo 2: Los nanomateriales y sus superpoderes.

¿Cómo podemos fabricar en serie productos sofisticados con materiales demasiado pequeños para verlos?

Módulo 3: Riesgos de los nanomateriales.

Riesgos para la seguridad de los nanomateriales. ¿Son peligrosas las nanopartículas artificiales? Y si lo son, ¿cómo evaluamos los riesgos para la salud y garantizamos su seguridad? (Ramanathan 2019)

La Figura 1 muestra la información suministrada en el curso on-line, de manera que los estudiantes pudieran seguir el orden de aprendizaje propuesto para el curso. A lo largo de este curso previo, se pudo tener conversaciones en grupo y discusiones con expertos en Nanomateriales del centro NanoGune (San Sebastián) y MaterFad (Barcelona).

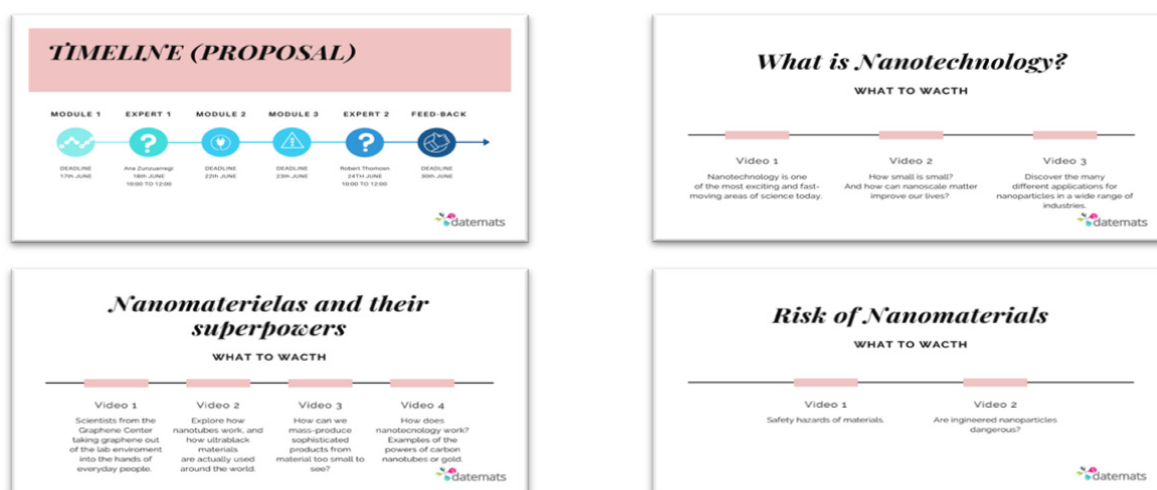


Figura 1. Información suministrada en el curso on-line

UNDERSTANDING EM&T DISCOVER Introduction/learning EM&T	EXPLORING EM&T DEFINE Ideation/Concepts	APPLYING EM&T DEVELOP Selection/Modeling low fidelity	APPLYING EM&T DELIVER Applying	PRESENTATION
Monday	Tuesday	Wednesday	Thursday	Friday
9.00 Welcome City, University Students introduction 9.30 Present workshop Objectives Agenda	9.00 Define Market/competitor analysis Creativity	9.00 Develop Concept selection 9.30 Develop MindMap Brainstorming Techniques TGN Low fidelity prototypes	9.00 Deliver 3D models High Fidelity prototypes + + 10:00 EM&T Pill (Company 04) Graphenea	9.00 Deliver High Fidelity prototypes Materials Concepts Concept presentation material
10:30 Coffee Break	-	-	-	-
10:45 Understand EM&T Theory Robert Thompson	11.00 Define Sketching, drawings + + 11:30 EM&T Pill (Company 02) Burdinola	-	-	11.00 Preparing presentations
12:15 Company 01 Briefing presentation Launch Challenge Antolin Group	-	-	-	12:30 EM&T Pill (Company 05) Celt
13:15 - 14:15 Lunch	-	-	-	-
14:15 Exploring EM&T Experimentation of EM&T 30"x4"x120" Practices in lab Toolkit Robert Thompson	14.00 Define Sketching, drawings 16.00 Presentation 5 min group	15.00 EM&T Pill (Company 0) Ikerlat 16.00 Presentation 5 min group	-	14.00 Final presentations 15 min group Exhibition Evaluation 16.15 cuestionario final 16.30 Closing
16:30 Groups	-	-	-	-
17:00 End of session	-	-	-	-

Figura 2 Plan de trabajo del taller

2.2 Taller de nanomateriales

2.2.1 Plan de trabajo

El plan de trabajo del taller se muestra en la Figura 2. Durante el taller, se formaron equipos de trabajo multidisciplinares, compuestos por diseñadores e ingenieros, de diferentes procedencias de Europa. Para lograr un nivel de eficacia y validez en el proceso, el taller se estructuró con el objetivo de asegurar tanto la calidad de la aportación como la capacidad de la comunicación de la propuesta. Estimulando la creatividad mediante técnicas que se adecuaron a un público multidisciplinar. Se trató de explicar en términos sencillos a través de historias e imágenes, viendo la eficacia con la que podemos aplicarlo en un proceso creativo. Empezaron a concebir la idea plasmando los conocimientos adquiridos en ideas reales cuya función fuera aplicar los principios relativos a los comportamientos físicos y químicos de los diversos materiales nanométricos.

Durante el inicio de los talleres, se informó a los estudiantes sobre los resultados esperados del trabajo en equipo. Estos incluyeron una presentación final, un prototipo físico de la solución (si es posible) y un póster. Estos resultados fueron útiles para las actividades de difusión como resultado de los nuevos métodos.

- En cuanto a la presentación, cada equipo debía preparar una breve presentación de 10 a 15 minutos para el último día del taller para explicar la solución entregada. Esta breve presentación estuvo dirigida a la empresa que propuso el reto, para que pueda entender y retroalimentar al equipo.
- En cuanto al prototipo, se pidió a los estudiantes que crearan un prototipo físico de la solución para apoyar la presentación oral. Según la solución y el EM&T, algunos prototipos fueron más fáciles de crear.
- En cuanto al póster, cada equipo elaboró un cartel siguiendo una plantilla proporcionada por los investigadores de cada universidad (Figura 4). La plantilla incluía secciones en las que cada equipo

describía el proyecto, la cantidad de EM&T involucrados y el nivel de preparación de la propuesta relacionada con el mercado.

Los hitos más importantes de este Taller se presentan en los siguientes apartados.

2.2.2 Exposición del reto: Workshop in situ

Los estudiantes que participaron en el Workshop pertenecían a las cuatro universidades europeas participantes, de últimos cursos de carrera, de formación en diseño e ingeniería. En dicho taller se trabajó sobre un reto expuesto por el Grupo Antolín. Esta empresa comenzó su andadura como un taller mecánico (especializado en la reparación de vehículos y maquinaria agrícola) en Burgos, España, y dirigido por Avelino Antolín López y sus hijos Avelino y José.

Al día de hoy, el Grupo Antolín es una multinacional líder en el desarrollo, diseño y fabricación de componentes de interior para la industria del automóvil (Techos, Puertas, Iluminación y Cabinas y Consolas). Una empresa fuerte y competitiva implantada en 26 países en la que más de 30.000 personas desarrollan su talento. La creatividad, el liderazgo y la satisfacción del cliente siguen siendo sus valores fundamentales hoy en día y son su mejor receta para el éxito en el futuro.

Las conferencias iniciales corrieron a cargo de especialistas en nanomateriales del grupo Antolín, los cuales abordaron en detalle la naturaleza y los comportamientos de los nanomateriales. Se hizo especial hincapié en la exploración en profundidad de temas relacionados con las nanofibras de carbono GANF, proporcionadas por el grupo Antolín. Tras su exposición, Antolín procedió a lanzar su reto a los estudiantes implicados en el taller. Aunque uno de los principales objetivos del proyecto era centrarse en aplicaciones innovadoras de nanofibras de carbono en el interior de vehículos (principal área de especialidad industrial de Antolín), se solicitaron otras innovaciones no dirigidas para encontrar aplicaciones alternativas en sectores

Tabla 2. Empresas participantes en el Workshop.

Graphenea https://www.graphenea.com/	Ikerlat http://www.ikerlatpolymers.es/?lang=es	Ceit-BRTA https://www.ceit.es/	Burdinola https://www.burdinola.com/es/e
Productor de grafeno de alta calidad. Diseñan, fabrican y suministran chips y materiales basados en grafeno para sus necesidades industriales y de investigación.	Especialistas en el desarrollo y fabricación de partículas poliméricas personalizadas. En la actualidad, con una trayectoria de quince años, la empresa se ha consolidado como un referente en el mercado de las dispersiones poliméricas.	Centro de investigación sin ánimo de lucro cuya actividad principal es llevar a cabo proyectos de investigación en colaboración con organizaciones. Entre otros campos, investigan sobre bioaplicaciones de nanomateriales.	Proveedor integral para trabajar con seguridad los nanomateriales. Llevan a cabo los proyectos de laboratorio más seguros y eficientes del mundo, laboratorios en los que los investigadores disfrutan trabajando para hacer del mundo un lugar mejor.
Esta empresa aporta conocimiento acerca del grafeno como el material más ligero y resistente, con gran capacidad para conducir el calor y la electricidad y que permite integrarlo en un gran número de aplicaciones.	Esta empresa aporta conocimiento sobre la fabricación personalizada de nanopartículas utilizadas como recubrimientos o para diagnósticos clínicos.	Ceit aporta conocimiento sobre aplicaciones micro y nano en el sector de la bioingeniería.	Esta empresa aporta conocimiento sobre el equipamiento necesario para poder trabajar con seguridad con los nanomateriales, aportando valor en el desarrollo de procesos industriales de la automoción.

completamente ajenos (es decir, envases, agricultura).

2.2.3 Píldoras didácticas durante el Taller

A medida que avanzaba el taller, se invitó a los participantes a examinar otros principios relacionados con los nanomateriales, en general, mediante la exposición a píldoras didácticas proporcionadas por otras empresas líderes en diferentes aplicaciones de los nanomateriales (recogidas en la Tabla 2). Las píldoras se seleccionaron estratégicamente para ofrecer una exposición completa de los diversos aspectos que rodean a los nanomateriales en general, con el objetivo de ampliar su potencial de uso y, al mismo tiempo, proporcionar una visión de las limitaciones y requisitos de seguridad necesarios cuando se trabaja con partículas submicrónicas. Las sesiones de píldoras abarcaron diferentes aspectos y ámbitos de la aplicación e investigación, desde la medicina a la producción de energía, la nutrición y la nano-electrónica.

2.2.4 Kit de materiales

El contenido didáctico divulgado en las conferencias se vio corroborado por una

serie de kits de herramientas de materiales individuales, producidos para uso público en forma de una carpeta de cajas que contenía muestras de materiales (ver Figura 3) y un conjunto colectivo de guías informativas de referencia rápida (ver Figura 4). Estos kits fueron desarrollados en el marco del proyecto DATEMATS, de cara a hacer visibles las propiedades de los 4 materiales elegidos por cada una de las 4 universidades participantes en el proyecto [más información en <https://www.datemats.eu/toolkit/>]. Cada caja estaba concebida para representar un único material. Albergaba folletos correspondientes que recogían las propiedades de este material, así como los métodos de producción, uso, propiedades, peligros para la seguridad y niveles de preparación tecnológica relacionados. Los kits de herramientas son un componente crucial y objeto de evaluación en esta metodología de taller, ya que representan la solución a una brecha didáctico-creativa (Piselli et al., 2018a) que existe actualmente en el campo del diseño. Dado que la mayor parte de la innovación se ve lastrada por la falta de conocimientos y de acceso a fuentes fiables de información necesaria para los avances, -especialmente en el ámbito concreto de la ciencia de los materiales- los kits de herramientas



Figura 3. Muestra de las cajas de los materiales



Figure 4. Muestra de los folletos con la información de varios nanomateriales ©Datemats-Materialy

representan un intento de concebir una fuente de consulta fácil de usar que salve esta brecha y permita una aplicación más segura de los materiales con un mayor grado de intención inspiradora. Para ello, los kits de herramientas han sido concebidos para proporcionar una combinación de aportaciones sensoriales e intelectuales derivadas del acceso a una muestra física de material y a una colección de bibliografía explicativa, respectivamente.

Se incluyó una muestra de material de pequeñas dimensiones dentro de un vacío central de la estructura de la caja y se dejó abierta y accesible a los usuarios para que pudieran tocar el material y evaluar sus cualidades sensoriales en directo. Alrededor de la muestra hay varios bloques de información logística y de identificación que contienen el nombre comercial, la clase y una información de contacto del fabricante. Entre los temas de información divulgativa, los materiales también se señalan por sus formatos disponibles, colores, acabados y perfiles físico-químicos. El objetivo principal de las tablas de clasificación de propiedades

era transmitir al usuario una visualización cualitativa rápida de las cualidades relativas y comparativas del material en todas y cada una de las propiedades distintivas, permitiendo en última instancia al usuario extrapolar una o más aplicaciones intuitivas del material con una base de confianza.

2.5. Nanomateriales presentados en el Taller

Se presentaron al alumnado cuatro nanomateriales: 1) GANF, 2) Bionox, 3) Grafylon y 4) Nanotex con el objetivo de cubrir un amplio espectro de aplicaciones de las nanopartículas en el sector de la automoción.

1. Las nanofibras de óxido de grafeno a base de carbono GANF, son estructuras submicrónicas cultivadas al vapor con una relación de aspecto alargada y una longitud total inferior a 100 micrómetros. Poseen una gran tenacidad y resistencia a la tracción a los sustratos de materiales y, dependiendo de las concentraciones, pueden proporcionar varias funciones distintas, como filtrado y/o elevada dureza superficial, una protección anticorrosiva. Además, pueden conducir el

calor o convertirse en un sustrato sobre el que pueden depositarse otros metales para mejorar la conducción electrónica o la capacitancia optoelectrónica.

2. Bionox, producido por Apta Colour son partículas nanométricas de TiO₂ de un tamaño comprendido entre 10 y 100 nanómetros las cuales confieren propiedades fotocatalíticas a los materiales. La fotocatalisis es un fenómeno optoquímico en el que, al absorber la luz solar y en presencia del oxígeno circundante (aire), los pigmentos de TiO₂ adquieren capacidades catalíticas y, por tanto, son capaces de acelerar la mineralización de determinados contaminantes a estados oxidados. Además, las partículas de TiO₂ poseen propiedades tensioactivas que, como efecto secundario, favorecen las propiedades antiincrustantes de las superficies gracias a su gran afinidad con la película de agua que se forma sobre ellas, haciéndolas menos pegajosas a las pinturas y a las partículas de suciedad. Las partículas de TiO₂ también poseen propiedades oxidativas que tienen un efecto bactericida en la mayoría de los casos. Relativamente no tóxicas, estas partículas también pueden aportar modificaciones reológicas a líquidos viscosos para aplicaciones industriales.

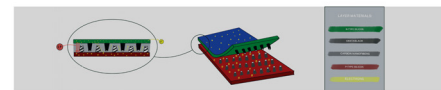
3. Grafylon producido por Direct Plus. Es un compuesto de filamentos a base de polímero PLA con una baja fracción de volumen de nanoestructura de grafeno dentro de su matriz. Se sabe que el grafeno posee una gran resistencia mecánica y una gran conducción eléctrica y térmica. Incluso en fracciones de volumen bajas, los sustratos poliméricos pueden adquirir numerosas ventajas, como una buena dispersión y disipación térmica, una excelente reproducción del molde y la integrabilidad en estructuras eléctricas. Además, el grafeno dentro de los polímeros otorga varias mejoras, como dureza superficial y resistencia al impacto y a la propagación de grietas, incluso a temperaturas más bajas.

4. Nanotex de Crypton es un aditivo de nanopartículas de SiO₂ que puede incrustarse en matrices de fibras textiles



New concept of streetlight powered by a 3 dimensional solar panel. Thanks to the form of the panel and the mirrors, the implementation of GANF material, the efficiency of the product is improved due to the increased amount of surface.

The product includes a rotational system activated by photo sensors (LDR sensor) what allows the panel to be orientated to the sun as long as possible during the day time. The improvement of the performance allows not only to power the streetlights but also to capture the surplus of the energy that can be used to charge e.g. electric cars, bikes and provide electricity to the households.



Feasibility of the idea.

CONCEPTION ☐ READY-TO-MARKET

Areas of materials involved. Material integration feasibility.

The main idea is to use the carbon nanotubes as filters and sensors in the solution proposed. It would help to capture the CO₂ produced and measure the evolution level in the filtration process. Nanotubes are playing a crucial role to enhance the chemical process of capturing CO₂ and producing water. Furthermore in the chemical process, the filters have to be dried. Also the thermal conduction of the nanomaterial plays an important role to fulfil this condition. The solution would allow companies to make profit of their own pollution while selling the captured elements to agricultural industries. The product still needs to be tested and elaborated to develop a fully functional solution.

#datemats #nanomaterials #renewableenergy #GrupoAntolin

Workshop at Tecnun, 27th-30th June 2020



The product is a combination of an automatic system combined with filters infused with carbon nanotubes that captures CO₂ and creates H₂O to feed plants in greenhouses.

This product has a double value that helps to reduce the contamination of CO₂ while assisting the growth of the plants optimizing the air cleaning further. It would function in the industrial factory chimney in collaboration with agricultural industry. It would be a service provided by the factory to generate more profit by selling this pollution. The principle of the concept is based on the following chemical reaction: $CO_2 + H_2O \rightarrow H_2CO_3$



Feasibility of the idea.

CONCEPTION ☐ READY-TO-MARKET

Areas of materials involved. Material integration feasibility.

The main idea is to use the carbon nanotubes as filters and sensors in the solution proposed. It would help to capture the CO₂ produced and measure the evolution level in the filtration process. Nanotubes are playing a crucial role to enhance the chemical process of capturing CO₂ and producing water. Furthermore in the chemical process, the filters have to be dried. Also the thermal conduction of the nanomaterial plays an important role to fulfil this condition. The solution would allow companies to make profit of their own pollution while selling the captured elements to agricultural industries. The product still needs to be tested and elaborated to develop a fully functional solution.

#naningers#datemats #nanomaterial#emergingmaterial

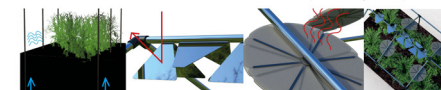
Workshop at Tecnun, 27th-30th June 2020



Interaction between CNF and the elements in a greenhouse

A temperature-controlled and water-collecting system that increases crop quality and opens up new possibilities for plants in new places.

Superior thermal conductivity and peculiar surface treatments given by the carbon nano fibers allow for a temperature-controlled and water-collecting closed system. Taking advantage of graphene energy, a renewable and reliable source of energy, the carbon nanotubes (CNT) rods efficiently transport constant along growth temperature (around 27°C) to the root zone. Further temperature regulation up to 27°C is achieved thanks to a light-passing CNF mechanism activated by shape memory alloys, that accumulates heat inside the greenhouse. The carbon nanotubes in the structure fabric enables water vapor to be collected by the plant roots, reducing water consumption, reducing



Feasibility of the idea.

CONCEPTION ☐ READY-TO-MARKET

Areas of materials involved. Material integration feasibility.

Integration of nanomaterials. Nanomaterials permit introducing smart and sustainable properties into the elements of the greenhouse. Optimum harvesting conditions could be achieved using the minimum amount of resources. The main idea is to use the carbon nanotubes as filters and sensors in the solution proposed. It would help to capture the CO₂ produced and measure the evolution level in the filtration process. Nanotubes are playing a crucial role to enhance the chemical process of capturing CO₂ and producing water. Furthermore in the chemical process, the filters have to be dried. Also the thermal conduction of the nanomaterial plays an important role to fulfil this condition. The solution would allow companies to make profit of their own pollution while selling the captured elements to agricultural industries. The product still needs to be tested and elaborated to develop a fully functional solution.

#nanomaterials #designinmaterialinnovation #emergingmaterialsandtechnologies #designinspiration

Workshop at Tecnun, 27th-30th June 2020

Figura 5. Imágenes de algunos de los pósters finales

como revestimiento repelente al agua y muy resistente, impidiendo así que las fibras absorban agua por dentro y por fuera. Las partículas de SiO₂ pueden aplicarse a los textiles mediante varios métodos, que en general mejoran la vida útil de los textiles al adquirir propiedades antiincrustantes y capacidades de autolimpieza, garantizadas por la naturaleza superhidrofóbica de las nanopartículas de SiO₂.

Dada la alta prioridad del GANF sobre los demás nanomateriales, se hizo hincapié en explorar sus aplicaciones potenciales en diversos sectores de necesidad e impacto innovador.

Los distintos grupos recibieron aportaciones específicas para fomentar ideas en cinco áreas diferentes, a saber, energía, alimentación, biología y control de la contaminación.

Resultados

Además de los resultados más tangibles del Taller en forma de posters y presentaciones (Ver Figura 5), se les pidió a los estudiantes que llenaran un cuestionario para evaluar diferentes aspectos del taller.

Con respecto a la metodología, los estudiantes opinaron que fue adecuada y el formato del taller útil para trabajar con nuevos EM&T. No obstante, sí resaltaron varios problemas inherentes al EM&T del taller. El primer problema de los nanomateriales es su “invisibilidad” y los fenómenos asociados. La mayor parte de su actividad es, en virtud de la escala y la velocidad de acción, imperceptible para los sentidos humanos y su conocimiento experimental necesita de laboratorios caros y especializados y equipos de alto coste. Es por ello que contar con expertos en estas materias que colaboren y hagan “sencillo” algo que es complicado de por sí, ha resultado una gran experiencia. El papel llevado a cabo por los expertos en nanomateriales y, el diálogo que establecen con los alumnos en las actividades fue uno de los aspectos más valorados por los estudiantes. Ante la pregunta de cuál fue el aspecto más valorado del Taller,

algunas respuestas fueron: I value Robert a lot. He was incredibly helpful. Most valuable was the flood of knowledge from Robert, Having a person like Robert to guide us, work with a new technology that is not realistically applicable now. El experto ayudó a los alumnos a evolucionar desde ideas muy abstractas sobre los nanomateriales hacia un conocimiento más exhaustivo de los fenómenos que se esconden detrás de sus “superpoderes”. El uso de diagramas pictóricos y vídeos que mostraban los métodos de producción de los nanomateriales ayudó a los expertos a vincular la narración de historias para ayudar a los alumnos a asimilar los nuevos conocimientos y rellenar sus lagunas ontológicas y lingüísticas.

Con respecto al kit físico de materiales, su valoración por parte de los estudiantes fue muy positiva (90% le dieron una puntuación de 5) aunque echaron de menos una versión digital para consultarla fuera del Taller. Se confirmó que la información de carácter bibliográfico aportado en las hojas del kit era muy fácil de entender (68,2% lo valoró con un 5 y el 18,2% con un 4).

Finalmente, las empresas participantes, tanto lanzando un reto a los alumnos como compartiendo con ellos las píldoras de conocimiento sobre sus experiencias, fue clave para los estudiantes. De alguna manera, a partir de las experiencias vividas por las empresas de diferentes sectores y contextos, en su viaje hacia el desarrollo de soluciones industriales basadas en nanotecnología y su relato de ensayo y error compartido con los alumnos, se generó una biblioteca de “lecciones aprendidas en la piel de otros”. Este corpus de conocimiento experiencial transferido a los estudiantes compensó la imposibilidad de tener sus propias experiencias prácticas. Los estudiantes se dieron cuenta como los nanomateriales son un área de creciente interés para muchas empresas innovadoras de un gran abanico de sectores diferentes que puede contribuir a su empleabilidad en su futuro profesional.

Conclusiones

A lo largo de este trabajo se ha visto la importancia de la adecuada elección de un material a lo largo del proceso de diseño de un nuevo producto. Cuando este material es un material emergente con propiedades que le hacen idóneo, resulta difícil su conocimiento. Poder realizar un reto, de la mano de empresas punteras en estos ámbitos, resulta de gran interés.

Las “habilidades prácticas”, en el caso de los nanomateriales, no están tan relacionadas con las habilidades técnicas o experimentales de un diseñador o ingeniero, como en los otros casos de materiales emergentes, sino con las “habilidades sociales”. El conocimiento de los nanomateriales es uno de los ámbitos más interdisciplinarios ya que abarca disciplinas como la física aplicada, la ciencia de los materiales, la química física, la física de la materia condensada, la bioquímica y la biología molecular, y la ciencia y la ingeniería de los polímeros. En este contexto, el papel del diseñador, como facilitador, traductor y coordinador de un proceso de integración de diferentes áreas de conocimiento relacionadas con los nanomateriales, es fundamental para transformar el potencial de la nanotecnología en productos y aplicaciones comercializables. Las “habilidades sociales”, que los estudiantes desarrollan con nuestro método, pueden describirse como la capacidad de establecer un diálogo multidisciplinar y un proceso de traducción con el objetivo de desarrollar funciones innovadoras basadas en la nanotecnología para un producto o aplicación.

Los aspectos formativos pueden mejorarse con herramientas adicionales al conjunto de herramientas presentadas en el workshop mediante el desarrollo de herramientas de gamificación físicas o digitales que puedan ayudar a los estudiantes a comprender y aprender de una forma más experiencial e interactiva los diferentes fenómenos relacionados con los nanomateriales y su potencial de aplicación.

Agradecimientos:

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Research Article | Artículo de investigación

New methods and tools applied for the transfer of knowledge of nanomaterials: A design challenge for Grupo Antolin's company | Nuevos métodos y herramientas aplicados para la transferencia de conocimiento de los nanomateriales: Un reto de diseño para la empresa de Grupo Antolín

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Abstract:

In any product design process, the designer must take into account both the materials and technologies with which he/she must work. Currently, materials and technologies are becoming one of the main elements to foster innovation and add value to final products. Among the many materials, nanomaterials are of particular interest. Nanotechnology is set to play a key role worldwide in the 21st century, as it is a cross-sectoral technology, increasingly relevant to economic fields such as chemistry, medical technology, automotive or food industry. But, if the designer does not know how to work with it and wants to know the scope of this new material, how to transfer this knowledge, related to nanomaterials, from theory to practice? The industry demands experts (designers) who can bridge the gap between theoretical knowledge and practical applications of nanomaterials: products, services and experiences. This article presents a method of knowledge transmission, in which two main tasks can be distinguished: 1) a primary educational component, in which knowledge about new materials and their properties is disseminated in an optimal didactic way, and 2) a

second more practical component in which the information is converted into practical ideas and specific applications applied to a challenge proposed in collaboration with the Antolin group.

Keywords: Design Process; Design Education; Industrial Design; New Materials; Nanomaterials; Knowledge Transfer; Workshop

Resumen:

En todo proceso de diseño de producto, el diseñador debe tener en cuenta tanto los materiales como las tecnologías con los que debe trabajar. Actualmente, materiales y tecnologías se están convirtiendo en uno de los elementos principales para fomentar la innovación y agregar valor a los productos finales. Entre los múltiples materiales los nanomateriales presentan un especial interés. La nanotecnología está llamada a desempeñar un papel clave en todo el mundo en el siglo XXI, ya que se trata de una tecnología intersectorial, cada vez más relevante para ámbitos económicos como la química, la tecnología médica, la automoción o la industria alimentaria. ¿Pero, si el diseñador desconoce cómo se puede trabajar con él y quiere saber el alcance de este nuevo material? ¿Cómo transferir estos conocimientos, relacionados con los nanomateriales, de la teoría a la práctica? La industria demanda expertos (diseñadores) que puedan salvar la distancia entre el conocimiento teórico y las aplicaciones prácticas de los nanomateriales: productos, servicios y experiencias. Este artículo recoge un método de transmisión del conocimiento, en el que se pueden diferenciar dos tareas principales: 1) un componente educativo primario, en el que se divulgan, de una forma didáctica óptima, los conocimientos sobre los nuevos materiales y sus propiedades, y 2) un segundo componente más práctico en el que la información se convierte en ideas prácticas, y en aplicaciones específicas aplicadas a un reto propuesto en colaboración con el grupo Antolín.

Palabras clave: Proceso de diseño; Educación en diseño; Diseño Industrial; Nuevos materiales; Nanomateriales; Transferencia de conocimiento; Workshop

Introduction

The importance of materials over the centuries is reflected in how we talk about and recognize ancient civilizations in terms of the materials that were used in those eras. That is why we can recognize them as the Stone Age, the Bronze Age and the Iron Age. Later, after the Industrial Revolution, new materials and new transformation processes began to appear. Polymers, biomaterials and composite materials appeared, giving the product better performance. Nowadays, research continues into new materials, more sustainable materials or materials that are duly modified to give them new properties. We can affirm that materials play a very important role in industrial design since their objective is to create or redesign products with aesthetic and functional characteristics

that solve specific needs of people and society. An important key in product design and development is, therefore, the right choice of material to work with in order to achieve the best result. However, what if that material is an emerging material with better characteristics and therefore offers new applications, new and improved designs? But, we do not know how to work with it and how to know the scope of these new materials? We see how advances in the development of these emerging materials are opening up new possibilities for designers. Choosing the right material for a given product can be a complex task, but at the same time a key factor in the success of the product. Materials and technologies are becoming one of the main elements of product design practice as a

lever to foster innovation and add value to final products.

Often, when thinking about these new materials, or rather innovative materials, they are studied from a point of view exclusively related to their properties: chemical, physical (mass, weight, volume, density, electrical resistivity, thermal conductivity...), or mechanical (tensile behavior, compression, rigidity, hardness, brittleness, elasticity...). Moreover, they are studied either in relation to industrial practice or in relation to different subjects in the field of education. Therefore, these materials can revitalize design, create new business opportunities, transform industrial activities, and conceive more sustainable solutions and designs that are more creative.

So how to design with and for these new materials? How to understand the scope of new materials? How to transmit the knowledge developed in research centers and in universities to companies? How to make designers aware and give them the right expertise on how to take advantage of the enormous opportunities offered by advanced materials? How to see that design can thus develop its full potential as a driver of innovation and European competitiveness?

A gap can be seen between creative design and the research and development of new materials and technologies to be used in new products. In addition, at the heart of the problem is a lack of collaboration between researchers and the creative industries.

Within the framework of emerging materials, the ones that we have identified as being of particular interest are nanomaterials [P. (Morer, 2020)]. Nanotechnology is set to play a key role worldwide in the 21st century, as it is a cross-sectoral technology, increasingly relevant to economic fields such as chemistry, medical technology, automotive or the food industry. It is a challenge for industries to know how to apply nanomaterials and obtain new industrial products with improved properties (anti-graffiti, anti-corrosion, flame retardant,

anti-fungal, anti-friction, anti-grease and oil, anti-bacterial, self-cleaning, dry lubricants, polishers, photocatalytic applications, etc.).

The question is HOW to transfer this knowledge, related to nanomaterials, from theory to practice. Industry demands a growing need for experts (designers) who can bridge the gap between theoretical knowledge and practical applications of nanomaterials to develop new products, services and experiences.

This article presents the specific didactic and creative techniques used in a workshop carried out in collaboration with the Antolin Group, manufacturer and supplier of carbon nanofiber helicoidally fibers.

Methodology

Materials and technologies have been seen to be a vitally important topic in Design Education curricula. This area is known to need continuous updates (Zhou et al., 2019). They are in continuous development. Design professionals and students need to continuously acquire knowledge, skills and competences, not only to leverage the possibilities of available materials in their designs but also to contribute to the innovation and development of new materials (Haug, 2018). We have transitioned from a 'hard' profile approach primarily based on science (Ashby et al., 2007) (Myerson Report, 1991), to a 'soft' profile approach that places more emphasis on the didactic approach to teaching materials (Rognoli et al., 2004; Rognoli, 2011; Karana, et al., 2010; Zuo, 2010; Van Kesteren, 2010; Karana et al. 2013), and on "design-led" approaches (Ashby et al., 2007) (Myerson Report, 1991), which involve understanding needs, direct experimentation with materials, and discussion with experts. In this framework, methods such as Active Learning (Bonwell & Eison, 1991) and Experiential Learning (Kolb, 1984) are fundamental approaches to teaching and learning, engaging students in design challenges with companies (Piselli, et al. 2018), and learning through creation (Pedgley, 2010).

It is also observed that R&D areas promote methodologies based on the execution of different workshops, in which didactic-creative programs are carried out, specifically designed to stimulate the creative perception of the participants. It is particularly interesting to find ideal "uses" for emerging materials and related technologies (EM&T) derived from R&D advances in the fields of materials science and engineering.

Among these methods of knowledge transfer we can distinguish two main tasks: 1) on the one hand, a primary educational component, where knowledge about new materials and their properties is disseminated in an optimally didactic way, and on the other hand, 2) where information is converted into practical ideas, suitable for specific applications. While the first task focuses on the dissemination of factual data, relating to quantitative aspects of a scientific nature, the second step is a more qualitative and intuitively inspired means.

Both tasks were carried out within the framework of a workshop, in which a total of 25 students from four European universities (School of Design from Politecnico di Milano; School of Chemical Technology from Aalto University; Material Design Lab from Copenhagen School of Design and Technology; School of Engineering from Universidad de Navarra-Tecnun) and companies from the sector took part. During the workshop, they were presented with a challenge to be solved by a leading company such as Grupo Antolin. One of the first steps focused on the dissemination of the different nanomaterials and their properties. The

information was transmitted orally with an extensive supporting glossary on the specific terminologies used to describe the phenomena that can be expected to occur in the nanomaterials sector and the manufacturing processes. Since most of the activity of nanomaterials is not perceptually evident, but in fact imperceptible to the senses, the didactic content covered in the lectures was delivered in a specialized way to allow understanding of the content through explanatory theoretical models supported by various forms of infographic support, delivered in parallel.

2.1. How to get into nanomaterials: Online Course

Prior to the on-site workshop, a first course was held in an on-line format, in which students were introduced to the basic and key concepts related to nanomaterials. This learning course was divided into three parts, as shown in table 1 below:

Part 1: Introduction. This part was divided into three modules:

Module 1: What are nanomaterials and nanotechnology?

It introduced concepts such as what nanotechnology is, what we mean by small, and how can it improve our lives. It also explored how nanotechnology investigates the science and engineering of matter at the nano-scale. Nanotechnology involves manipulating and controlling matter from one nanometer to 100 nanometers. It highlighted the various applications of nanoparticles in sectors as diverse as computing, energy, transport, health and environmental protection.

Table 1. Structure of the on-line course.

When	What	Who	Where
Part 1: Introduction (1-2h) Video presentation of the objective of this activity. Watching videos (7-10 min each) (TED Talks, YouTube...) Quizzes with questions that can help students increase their understanding of the basic concepts.	Key concepts, inspiring talks.	Tutors	Online - link
Part 2: Question and answer session and homework Conversation or discussion in groups (max. 1h). Discussion with supervisors and/or experts on the videos and materials from Part 1. Preparation of questions for experts	Small group discussions to discuss and explore materials, technologies and cases in more depth	Supervisor Tutors Experts	Online - Meet
Part 3: Collect feedback (max 20 min) Online questionnaire	Students Feedback	Supervisor Tutors	Online - link

Module 2: Nanomaterials and their superpowers.

How can we mass-produce sophisticated products with materials that are too small to see?

Module 3: Risks of nanomaterials.

Safety risks of nanomaterials: Are engineered nanoparticles dangerous? Moreover, if they are, how do we assess the health risks and ensure their safety? [A. (Ramanathan, 2019)]

Figure 1 shows the information provided in the online course, allowing students to follow the suggested learning order. Throughout this pre-course, students had the opportunity to engage in group conversations and discussions with experts in Nanomaterials from the NanoGune center (San Sebastian) and MaterFad (Barcelona).

2.2 Nanomaterials workshop

2.2.1 Work plan

The work plan for the workshop is shown in Figure 2. During the workshop, multidisciplinary teams were formed, consisting of designers and engineers from different European backgrounds. The workshop was structured to ensure efficiency and validity in the process, focusing on the quality of input and effective communication of proposals. Creativity was stimulated using techniques suitable

for a multidisciplinary audience. The objective was to explain complex concepts through stories and images, assessing their applicability in the creative process. The participants started generating ideas by applying the knowledge they had acquired, aiming to incorporate the principles related to the physical and chemical behavior of various nanometric materials into tangible concepts.

During the beginning of the workshops, students were informed about the expected outcomes of their teamwork. These outcomes included a final presentation, a physical prototype of the solution (if possible) and a poster. These results were valuable for dissemination activities that emerged from the new methods.

Regarding the presentation, each team was required to prepare a concise 10-15 minutes presentation for the last day of the workshop, in which they would explain their proposed solution. This presentation was directed towards the company that had posed the challenge, allowing them to comprehend the solution and provide feedback to the team.

Regarding the prototype, students were tasked with creating a physical prototype of their solution to complement the oral presentation. The ease of creating prototypes varied depending on the specific solution and the related EM&T.

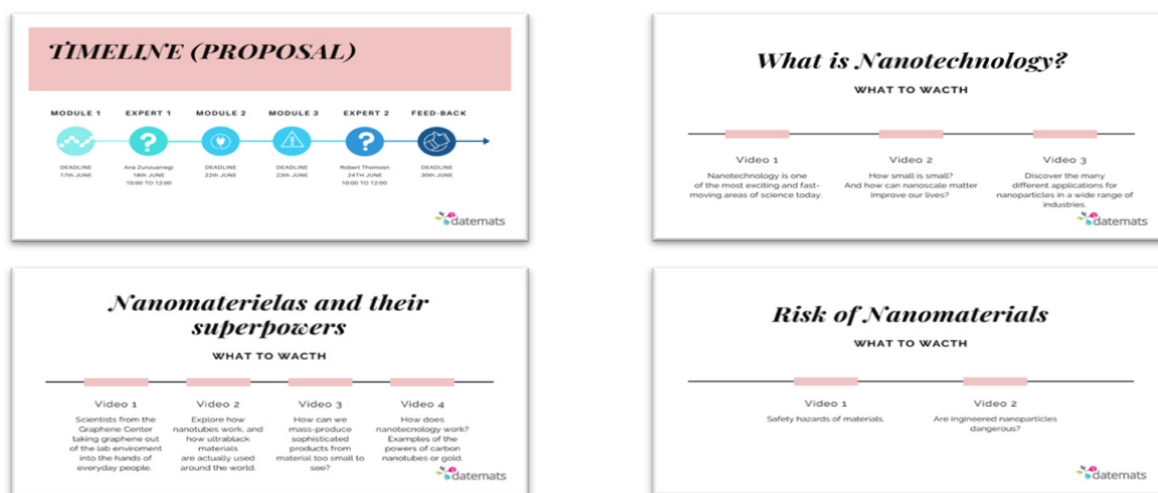


Figura 1. Información suministrada en el curso on-line

UNDERSTANDING EM&T DISCOVER Introduction/learning EM&T	EXPLORING EM&T DEFINE Ideation/Concepts	APPLYING EM&T DEVELOP Selection/Mockups low fidelity	APPLYING EM&T DELIVER Applying	PRESENTATION
Monday	Tuesday	Wednesday	Thursday	Friday
9.00 Welcome City, University Students introduction	9.00 Define Market/competitor analysis Creativity	9.00 Develop Concept selection	9.00 Deliver 3D models High Fidelity prototypes	9.00 Deliver High Fidelity prototypes Materials Concepts Concept presentation material
9.30 Present workshop Objectives Agenda		9.30 Develop MindMap Brainstorming Technics TGN Concept selection Low fidelity prototypes	- - - 10:00 EM&T Pill (Company 04)	
10:30 Coffee Break	-	-	Graphenea	
10:45 Understand EM&T Theory Robert Thompson	11.00 Define Sketching, drawings	-	-	11.00 Preparing presentations
12:15 Company 01 Briefing presentation Launch Challenge Antolin Group	11:30 EM&T Pill (Company 02) Burdinala	-	-	12:30 EM&T Pill (Company 05) Ceit
13:15 - 14:15 Lunch				
14:15 Exploring EM&T Experimentation of EM&T 30"x4x120" Practices in lab. Toolkit Robert Thompson	14.00 Define Sketching, drawings	15.00 EM&T Pill (Company 03) Ikerlart	-	14.00 Final presentations 15 min group Exhibition Evaluation
16:30 Groups 17.00 End of session	16.00 Presentation 5 min group	16.00 Presentation 5 min group		16.15 cuestionario final 16.30 Closing

Figure 2. Workshop work plan

For the poster, each team designed a poster using a template provided by the researchers at their respective university. The template included sections in which the team described their project, the extents of EM&T involved and the level of the market-related proposal preparation.

The following sections present the most significant milestones achieved during this workshop.

2.2.2 Exposing the challenge: On-site workshop

The students who participated in the workshop were enrolled in the final years of their degree courses at the four European universities involved, specializing in design and engineering. The workshop focused on a challenge presented by Grupo Antolin. Initially, Grupo Antolin a mechanical workshop in Burgos, Spain, founded by Avelino Antolin Lopez and his sons Avelino and Jose, specialized in vehicle and agricultural machinery repairs.

Today, Grupo Antolin has evolved into a leading multinational company engaged in the development, design, and manufacturing of interior components for the automotive industry including Headliners, Doors, Lighting, Cabins and Consoles. It operates in 26 countries, employing over 30,000 individuals who contribute their talents to the company's success. Creativity, leadership and

customer satisfaction remain fundamental values for Grupo Antolin, driving its future achievements.

Nanomaterials specialists delivered the opening lectures from Grupo Antolin, who provided detailed insights into the nature and behavior of nanomaterials. Significant emphasis was placed on an in-depth exploration of GANF carbon nanofibers, which were specifically provided by the Antolin group. Following the presentation, Antolin presented the challenge to the participating students. While the primary focus of the project on innovative applications of carbon nanofibers in vehicle interiors (Antolin's main area of industrial expertise), alternative and unrelated innovations were also encouraged, seeking potential applications in completely different sectors such as packaging or agriculture.

2.2.3 Didactic pills during the workshop

As the workshop progressed, participants were given the opportunity to explore additional principles related to nanomaterials in general. This was achieved through educational "pills" provided by prominent companies specializing in different applications of nanomaterials (as listed in Table 2). The selection of these "pills" was strategic, aiming to offer participants a comprehensive understanding of various aspects related to nanomaterials. The goal was to expand their

knowledge of potential applications while also highlighting the limitations and safety requirements associated with working with nanomaterials. The “pill” sessions covered diverse aspects and fields of application and research, ranging from medicine and energy production to nutrition and nano-electronics.

2.2.4 Toolkits

The didactic content presented during the conferences was accompanied by a series of individual materials toolkits, which were created for public use. These toolkits were organized in the form of a box folder, containing samples of materials (see Figure 3), as well as a collective set of quick reference information guides (see Figure 4). These kits were developed as part of the DATEMATS project, with the aim of showcasing the properties of the four materials selected by each of the four participating universities in the project [more information at <https://www.datemats.eu/toolkit/>].

Each box within the toolkit represented a specific material and included accompanying brochures that outlined its properties, production methods, usage, safety hazards, and technology readiness levels. The toolkits played a critical role in the workshop methodology and were subject to evaluation, as they addressed a gap in the design field that combines didactic and creative elements (Piselli et al., 2018a). In the field of materials science, where innovation often faces challenges due to a lack of knowledge and access to reliable information sources, the toolkits aimed to serve as user-friendly references

that bridge this gap and enable a more confident application of materials with a higher degree of inspiration. The toolkits were designed to provide both sensory and intellectual inputs, achieved through physical samples of materials and explanatory literature, respectively.

A small sample of the material was placed within a central void of the box, allowing users to touch the material and assess its sensory qualities. Surrounding the sample were several information blocks containing logistical and identification details, such as the trade name, class and manufacturer's contact information. The materials were also characterized by their available formats, colors, finishes and physic-chemical profiles... The primary purpose of the property classification tables was to provide users a quick qualitative visualization of the material's relative and comparative qualities in each distinctive property; ultimately, this allowed users to intuitively extrapolate one or more applications of the material with confidence.

2.5. Nanomaterials presented at the workshop

The students were introduced to four nanomaterials: 1) GANF, 2) Bionox, 3) Grafylon and 4) Nanotex. These nanomaterials were chosen to showcase a wide range of nanoparticle applications in the automotive sector.

1. GANF (carbon-based graphene oxide nanofibers) are submicron structures with an elongated aspect ratio and a total length of less than 100 gauge. They possess

Table 2. Companies participating in the Workshop.

Graphenea https://www.graphenea.com/	Ikerlat http://www.ikerlatpolymers.es/?lang=es	Ceit-BRTA https://www.ceit.es/	Burdinola https://www.burdinola.com/es/e
Producer of high quality graphene. Design, manufacture and supply graphene-based chips and materials for your industrial and research needs.	EsSpecialists in the development and manufacture of customized polymer particles. Today, with a track record of fifteen years, the company has established itself as a benchmark in the polymeric dispersions market.	CA non-profit research center whose main activity is to carry out research projects in collaboration with organizations. Among other fields, they research on bio-applications of nanomaterials.	One-stop provider for working safely with nanomaterials. They carry out the safest and most efficient laboratory projects in the world, laboratories where researchers enjoy working to make the world a better place.
This company brings knowledge about graphene as the lightest and strongest material, with the ability to conduct heat and electricity and to be integrated into a wide range of applications.	This company provides knowledge on the customized manufacture of nanoparticles used as coatings or for clinical diagnostics.	Ceit provides knowledge on micro and nano applications in the bioengineering sector.	This company provides knowledge on the equipment needed to work safely with nanomaterials, adding value in the development of industrial processes in the automotive industry.



Figure 3. Sample of boxes of materials



Figure 4. Sample brochures with information on various nanomaterials ©Datemats-Materialy

high toughness and tensile strength, which allows them to material substrates for functions such as for filtering, high surface hardness, and corrosion protection. , depending on the concentrations, can provide several different. Additionally, GANF can conduct heat and serve as a substrate for improving electronic conduction or optoelectronic capacitance by depositing other metals on them.

2. Bionox, produced by Apta Colour, are nano-sized TiO_2 particles from 10 to 100 nanometers. These particles impart photocatalytic properties to materials. Photocatalysis is an optochemical phenomenon in which TiO_2 pigments, when exposed to sunlight and surrounded

by oxygen; acquire catalytic capabilities, accelerating the mineralization of certain pollutants to oxidized states. TiO_2 particles also possess surfactant properties that enhance antifouling properties and posses bactericidal effects. They can also possess surfactant properties that enhance antifouling properties and possess bactericidal effects. They can also modify the rheology of viscous liquids for industrial applications.

3. Grafylon produced by Direct Plus, is a PLA polymer-based filament composite with a low volume fraction of graphene nanostructure within its matrix. Graphene is known for its high mechanical strength and electrical and thermal conductivity.

Even at low volume fractions, graphene within polymer substrates offers advantages, such as good dispersion, thermal dissipation, excellent mold reproducibility, and integrality in electrical structures. It also provides improvements in surface hardness, impact resistance and crack propagation resistance, even at lower temperatures.

4. Crypton's Nanotex is a SiO₂ nanoparticle additive that can be embedded in textile fiber matrices to create a water-repellent and highly resistant coating, preventing water absorption. SiO₂ particles can be applied to textiles using various methods, improving their lifetime by acquiring anti-fouling properties and self-cleaning capabilities due to the superhydrophobic nature of SiO₂ nanoparticles.

Given the emphasis of GANF among the nanomaterials, the focus of exploration was on its potential applications in various sectors with innovative need and impact. The different groups received specific input to generate ideas in four different areas: energy, food, and biology and pollution control.

Outcomes

In addition to the more tangible results of the workshop, such as posters and presentations (see Figure 5), students were also requested to complete a questionnaire to evaluate various aspects of the workshop.

With regard to the methodology, the students felt that it was appropriate and the workshop format useful for working with new EM&Ts. However, they did highlight several problems inherent in the EM&T of the workshop. The first problem with nanomaterials is their "invisibility" and associated phenomena. Most of their activity is, by virtue of the scale and speed of action, imperceptible to human senses and their experimental understanding requires expensive, specialized laboratories and expensive equipment. This is why having experts in these fields collaborate and make "simple" something that is complicated in itself has proved to be a

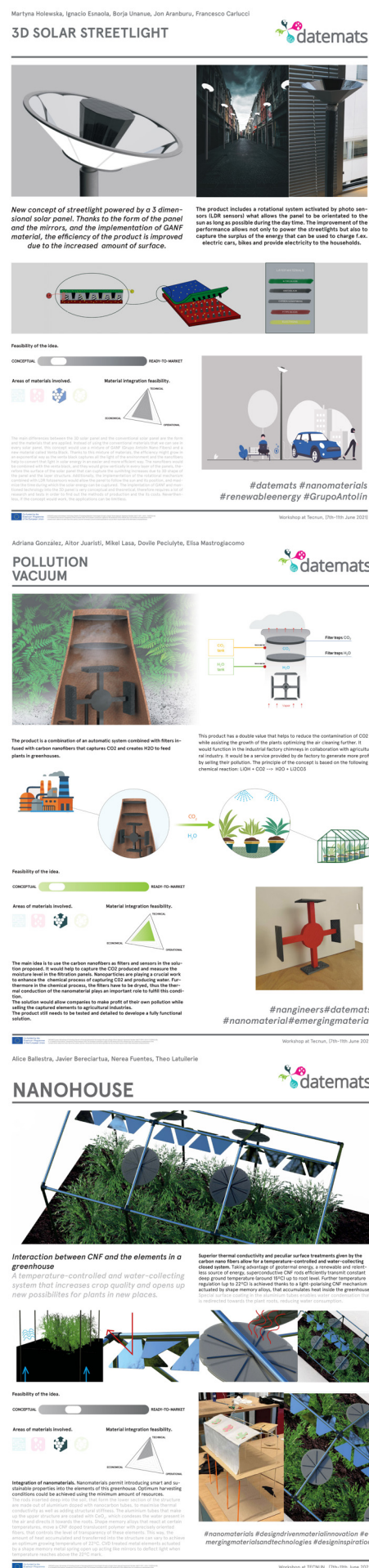


Figure 5. Images of some final posters

great experience. The role played by the nanomaterials experts and the dialogue they establish with the students in the activities was one of the aspects most valued by the students. When asked what the most valued aspect of the workshop was, some of the responses were: I value Robert a lot. He was incredibly helpful. Most valuable was the flood of knowledge from Robert. Having a person like Robert to guide us, work with a new technology that is not realistically applicable now. The expert helped the students to evolve from very abstract ideas about nanomaterials to a more comprehensive understanding of the phenomena behind their “superpowers”. The use of pictorial diagrams and videos showing the production methods of nanomaterials helped the experts to link storytelling to help pupils assimilate the new knowledge and fill in their ontological and linguistic gaps.

With regard to the physical kit of materials, its evaluation by the students was very positive (90% gave it a score of 5) although they missed a digital version to consult it outside the workshop. It was confirmed that the bibliographical information provided in the kit sheets was very easy to understand (68.2% rated it a 5 and 18.2% a 4).

Finally, the participating companies, both by issuing a challenge to the students and by sharing with them the knowledge pills about their experiences, was key for the students. In a way, from the experiences lived by companies from different sectors and contexts, in their journey towards the development of industrial solutions based on nanotechnology and their trial and error story shared with the students, a library of “lessons learned in the skin of others” was generated. This body of experiential knowledge transferred to the students compensated for the impossibility of having their own practical experiences. The students realized how nanomaterials are an area of growing interest to many innovative companies from a wide range of different sectors that can contribute to their employability in their future careers.

Conclusions

Throughout this work, we have significance the significance of selecting the appropriate material during the design process of a new product. When this material is an emerging one, possessing properties that make it an ideal choice, comprehending its characteristics becomes challenging. It is highly intriguing to engage in a collaboration with leading companies in these fields and tackle such challenges.

In the case of nanomaterials, “practical skills” are not solely related to the technical or experimental abilities of a designer or engineer, unlike other cases of emerging materials. Instead, they are focused on “social skills”. Nanomaterials knowledge is highly interdisciplinary, encompassing disciplines such as applied physics, material science, physical chemistry, condensed matter physics, biochemistry, molecular biology, and polymer science and engineering. In this context, the role of the designer, as a facilitator, translator and coordinator becomes essential in integrating diverse areas of knowledge related to nanomaterials. This integration is crucial to transform nanotechnology’s potential into marketable products and applications. The “soft skills” develop by students through our method, can be described as the ability to establish a multidisciplinary dialogue and translation processes with the goal of developing innovative nanotechnology-based functions for a product or application.

To enhance the formative aspects, additional tools can be incorporated alongside the toolkit presented in the workshop. This can involve the development of physical or digital gamification tools that provide students with a more experiential and interactive way to understand and learn tools that provide students with a more experiential and interactive way to understand and learn about the different phenomena associated with nanomaterials and their potential applications.

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ethical statement and good practices

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