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Design for Sustainability tools: a critical overview and a “tool navigator” for researchers & designers

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ABSTRACT/ASTRATTO

The field of Design for sustainability has seen a progressive evolution and recognition, moving from environmentally sustainable resource selection, to product design for environmental sustainability, to system design for sustainability (environmental protection, social inclusion and economic prosperity) over the last three decades.

In this context, several tools have been developed to support designer in the development process. This study gives research of Design for sustainability tools with a systematic literature review of articles, books and desk research of institute's websites and publications.

For each tool, the following factors are explored: (a) the general characteristic of the tool including the aim, the contents, the procedure to use the tool, the tool availability and necessary resources, the form, the developer etc.; (b) tool functions and typology; and (c) the tool integration in a design process.

As a result, this study proposes a Design for sustainability tools map "navigator" to support and enables the designers to deeply understand, organize, identify and use the appropriate tool according to her/his specific need.

Keywords: Design for sustainability, design tools, tools map

Il campo del Design per la sostenibilità ha visto un'evoluzione e un riconoscimento progressivi, passando dalla selezione di risorse sostenibili dal punto di vista ambientale, alla progettazione di prodotti per la sostenibilità ambientale, fino alla progettazione di sistemi per la sostenibilità (protezione ambientale, inclusione sociale e prosperità economica) negli ultimi tre decenni.

In questo contesto, sono stati sviluppati diversi strumenti per supportare i progettisti nel processo di sviluppo. Questo studio fornisce una ricerca sugli strumenti di design per la sostenibilità con una revisione sistematica della letteratura su articoli, libri e ricerche a tavolino su siti web e pubblicazioni dell'istituto.

Per ogni strumento sono stati analizzati i seguenti fattori: (a) le caratteristiche generali dello strumento, tra cui l'obiettivo, i contenuti, la procedura di utilizzo dello strumento, la disponibilità dello strumento e le risorse necessarie, la forma, lo sviluppatore, ecc.

Di conseguenza, questo studio propone un "navigatore" della mappa degli strumenti del Design for sustainability per supportare e consentire ai progettisti di comprendere a fondo, organizzare, identificare e utilizzare lo strumento appropriato in base alle proprie esigenze specifiche.

Parole chiave: Design per la sostenibilità, strumenti di design, mappa degli strumenti.

INTRODUCTION

Design for sustainability (Dfs) is an integrated design approach that focusses on eliminating negative impacts on environment and create positive impact for the wellbeing of people. It had become a significant and major research area (Zhen et al., 2015). The current challenging phase of making path for sustainability concerns all sectors of society which includes Manufacturing and Engineering (Rosen and Kishawy, 2012). For the development of product and processes it is primarily focussed on usage of environmentally friendly materials and resource efficiency. This approach is also contemplated as life cycle design process where information about total life cycle phases of products and effect on environmental and living things are integrated. At present, Design for sustainability which are used in industries have rapidly grown, mainly focussing on purposes of new product and process development.

The alterations towards sustainability needs some shifts in the way we process, consume and more in common the way we live in (Vezzoli et al. 2022). In the presence of innovation as a primary function, design plays a vital role in research and practices on sustainability. Research shows that, at the development of the design stage, nearly 80% of product's environmental impacts are analyzed. (Europen Commission 2020; Europen Commision et al.2012; Design council 2022; Charter and Tischner 2001). Especially, sustainable solutions are extended from role of Design (Vezzoli, Garcia and Kohtala 2021).

The history of DfS culture and practice has moved from individual products to systems of consumption and production, and from strictly environmental problems to a complex blend of socio-ethical, environmental, and economic issues over the last few decades. A large number of DfS tools have been proposed alongside the development of DfS (Vezzoli 2018; Ceschin and Gaziulusoy 2019; Elena Windolph, Schaltegger, and Herzig 2014). At present, facing the rapid growth of a large number of DfS tools present, users may be challenged with a high level of unreliability and lack of skills and capability to understand which tools are correct and how to use them for specific processes. This study aims to analyse the dfs tools and a navigator.

This brings us to the outline of this article. In the section 'Analyses', the paper describes the review of Dfs tools. The section "conclusion" presents a how tool navigator of DfS tools was made.

LITERATURE REVIEW & DESK RESEARCH

The selection of proclamations was performed according to several unified criterias:

- topic of interest (tools related to design for sustainability),
- type of proclamations (literature review, case study, original research);
- consecutive order (proclamations between 2012-2022).

The literature review it was done in Google scholar, Scopus, web of science and Polimi online library making use of keywords such as ' Design for sustainability' OR 'eco-design' OR 'design for environment' OR 'Life cycle design' OR 'sustainable product-service system design' OR 'circular economy' AND 'tool'.

There were 109 papers found after excluding duplicates from different databases. A first selection was made based on the content of abstracts to evaluate the relevance. After which, 58 publications were selected as the main targets of the review.

Corresponding to the literature review, desk research on DfS tools was conducted according to several unified criteria:

- Topic of interest,
- Institutions (academic institution, consultancy institution)
- Projects on DfS.

The desk research was performed utilizing keywords same to the literature review. When conducting the analysis, official websites and publications of institutions and projects served as the primary sources of information.

TOOL ANALYSIS & DESCRIPTION

The study analysed each tool in terms of:

- The aim/goals/function and content
- The detailed procedure for using the tool
- The integration in the typical system design method
- The expected outcomes from the tool
- The availability and necessary resources
- Developer(s)
- Sources of tool.

The aim of analysing how each tool can be integrated into the typical design process was to gain a better understanding of when, how and why each tool can be used. The typical system design method shown in figure 1 was used as a reference, connecting design for sustainability with the typical development processes and sub-processes for products, services and systems, adopted from (Vezzoli, Garcia, and Kohtala 2021; Vezzoli, Kohtala, and Srinivasan 2014; Vezzoli 2018).

The system design method is divided into five stages of product and/or product-service system design:

- Strategic analysis: Focuses on gathering information to understand the current context and transforming the information into insights to guide the exploration of potential promising solutions.
- Service strategic brief: Focuses on identifying innovative potential directions for the development of valuable solutions, using a systematic approach that considers/involves all stakeholders along the value production chain.
- Product and/or service concept design: Aims to create and select the most promising product and/or service concepts.
- Product and/or service detailed design: Focuses on developing the project's details to enable the implementation of the solution.
- Communication: Draws up documents to report on the sustainability characteristics of the designed solution.

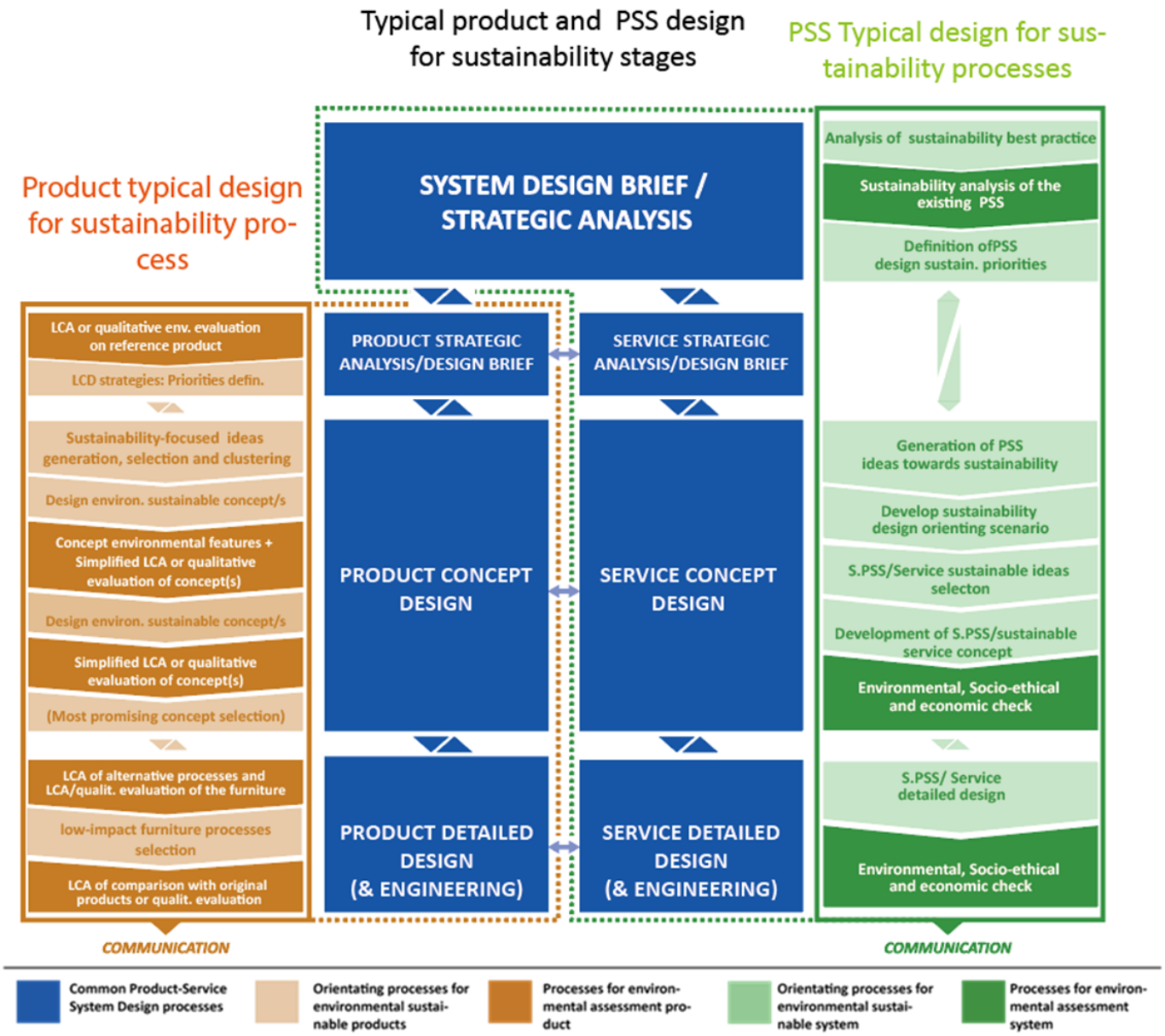

FIGURE 1. THE PROCESSES AND SUB-PROCESSES OF THE TYPICAL SYSTEM DESIGN METHOD ADAPTED FROM MSDS (VEZZOLI, GARCIA, AND KOHTALA 2021; VEZZOLI, KOHTALA, AND SRINIVASAN 2014) AND MPDS (VEZZOLI 2018)

The proposed method for environmentally sustainable system design presents processes for both the Product-Service System level (based on the Method for System Design for Sustainability, MSDS1, (Vezzoli, Garcia, and Kohtala 2021; Vezzoli, Kohtala, and Srinivasan 2014)) and the product level (based on the Method for Product Design for Sustainability, MPDS2, (Vezzoli 2018)).

As shown in figure 1, the presented method combines processes to be implemented along the Product-Service System (PSS) and the product design to show the important goal as follows:

- Assist designers in analysing the context of intervention and identifying product
- PSS design priorities; aid in the orientation of most promising sustainable solutions
- Evaluate the potential improvements of new solutions in terms of environmental sustainability

Finally, **the method was used as a reference** because it has a customizable structure with processes and sub-processes that can be easily adapted to the specific needs of designers/companies/organisations as well as diverse design contexts and conditions. In other words, users can choose to complete the entire process and related sub-processes, or a portion of the process(es) based on the specific requirements of one project.

TOOLS CLASSIFICATION & FUNCTION

Based on the total number of tools present, they were classified such as follows:

- **Tools for environmental sustainability evaluation (Product & System)**

Tools for environmental evaluation are the category of tools which are used to identify and reduce the impact on the environment of standard existing product or system, new product or system and during the development of a product or a system before the definition of design properties. From the figure 2 we see that environmental evaluation tools (products) are classified to qualitative and quantitative and in quantitative, it is further classified into all impact, complete & simplified LCA and mono impact evaluation.

In the fig3. the integration process in tools for environmental sustainability evaluation for product and systems is shown.

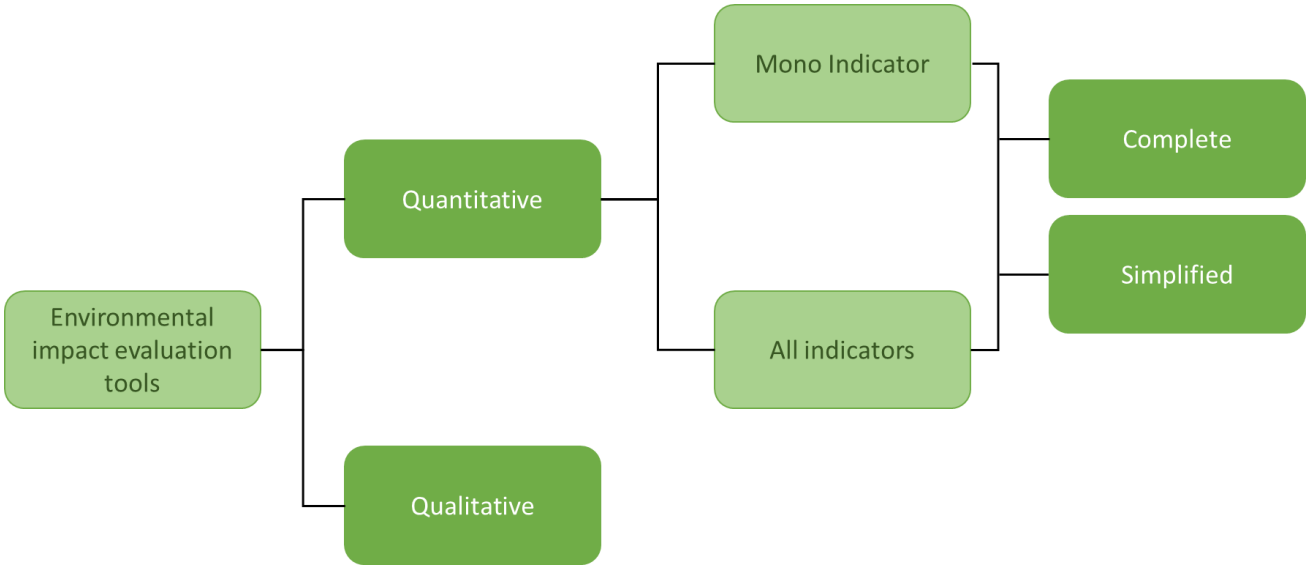

FIGURE 2 CLASSIFICATION OF ENVIRONMENTAL EVALUATION TOOLS

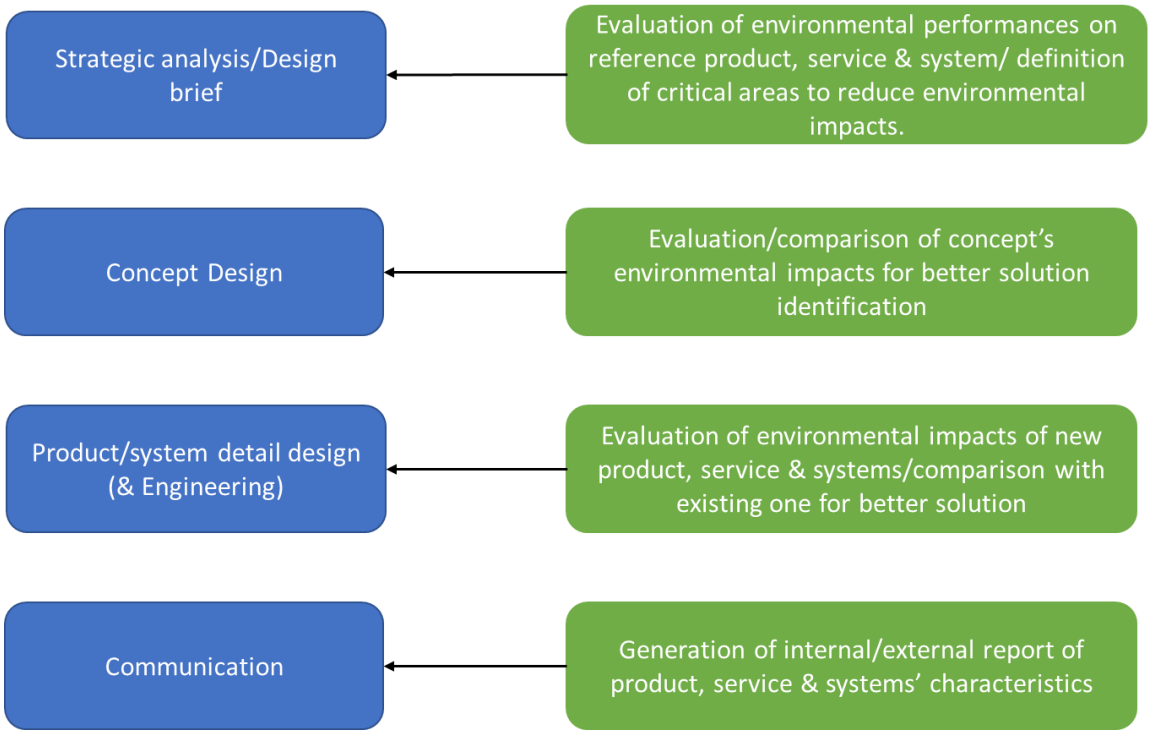

FIGURE 3 INTEGRATION PROCESS IN TOOLS FOR ENVIRONMENTAL SUSTAINABILITY EVALUATION FOR PRODUCT/SYSTEMS

➢ **Tools for environmental sustainability orientation (Product&System)**

These categories of tools are responsible for developing ideas and generating solutions. From the figure 4 we see that orientation tools for environmental generation solution (Product) are further classified into Dedicated tools for specific environmental performance, product comphrehensive life cycle design tools, specific tools for certain type of product, sector and firms and descriptive, organize and recording tool and internal communication. For the systems, it is categorized into general tools, sector specific tools and internal communication tools. The tools mostly developed in the form of checklists with statements or questions related to some design strategies/guidelines to direct the analysis.

In the fig5. the integration process in tools for environmental sustainability orientation for product and systems is shown.

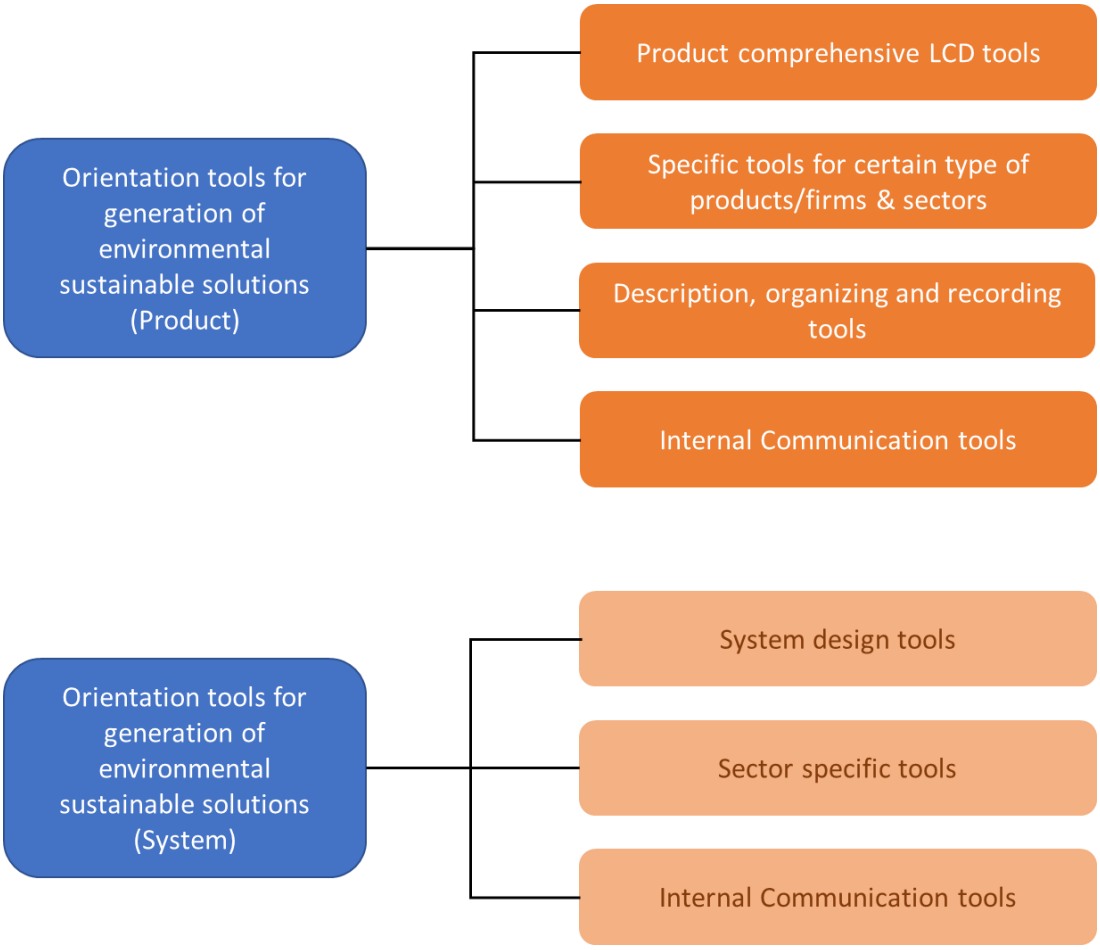

FIGURE 4 CLASSIFICATION OF ORIENTATION TOOLS FOR GENERATION OF ENVIRONMENTALLY SUSTAINABLE SOLUTIONS

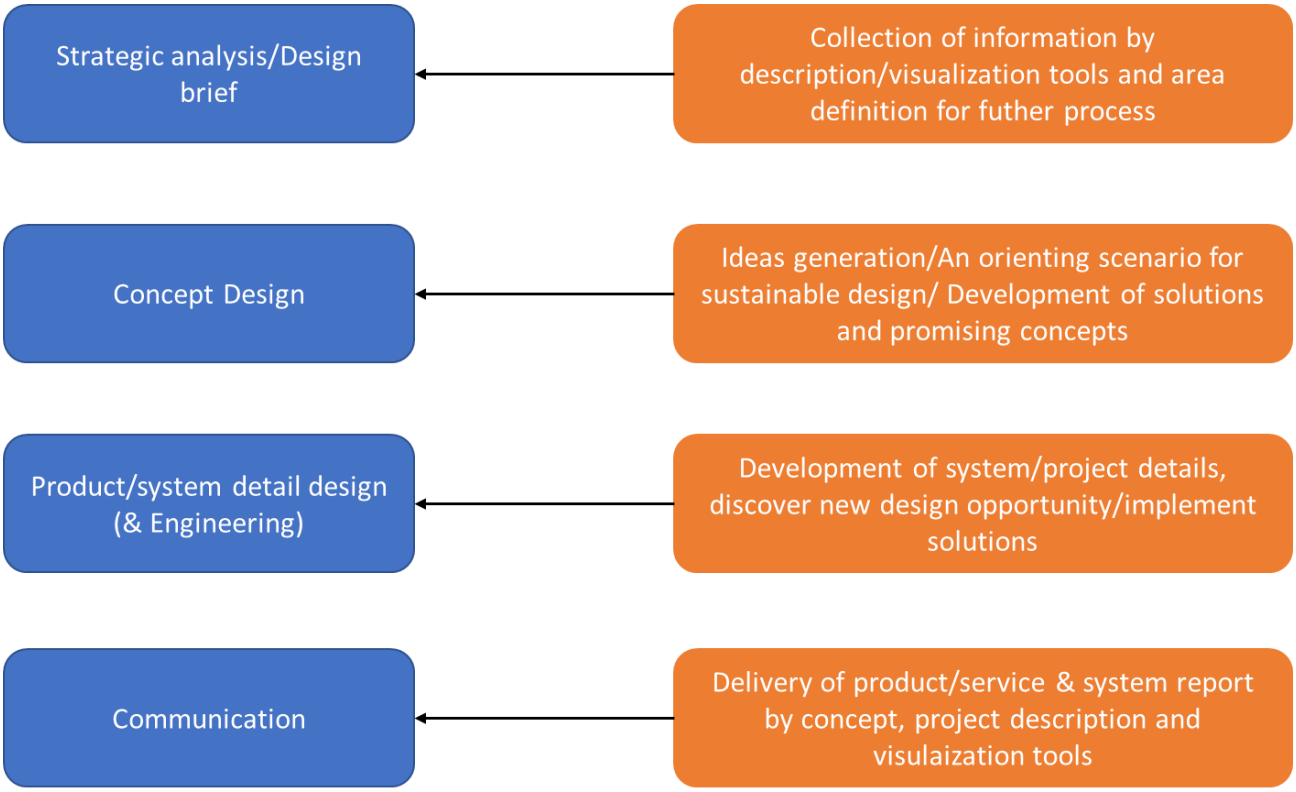

FIGURE 5 INTEGRATION PROCESS IN TOOLS FOR ENVIRONMENTAL SUSTAINABILITY ORIENTATION FOR PRODUCT/SYSTEM

ANALYSIS

The main aim is to identify the total number of designs for sustainability tools and characterize according to the several category/sub categories. Desk research was carried out for identifying each and every tool and its appropriate role/function is characterized. A literature review (Design for sustainability tools- DongFang Yang) showed the function of the tool and every process included in it. From this research there were 120 tools discovered.

Out of these 120 tools some tools were provided for example on how it is used/ works. The most important criteria showed here is how the tools are categorized and sub categorized.

Most promising part is that the flow of work is shown and also the examples of tools provided will have a quick glimpse on how to use Dfs tool for those who are new to the field. This research had been a good starting point for the tool classification, its appropriate function and integration process. Since it has a larger number of tools, user needs select the tool his/her specific needs. Among these totals of 120 tools, mostly many of the tools were open access and widely used in academic and education purposes and some are for industrial purposes.

The positive aspect about the design for sustainability tools were the ones in which tools comes under certain processes which makes the user understand the flow of process and easier to check tools in that working process. Negative aspect is that it consists of variety of tools and some overlaps in other function which makes it a little confusing for the user to know which tool is the overlapping tool.

This research presented a manual mapping on tools coming under each and every process/sub process will have the user to consume more time to identify and use the time. So, in this research, advantage is that workflow is accurate which will have an easier understanding whereas disadvantages is that not all research tool are shown so the user knows only tool's function that are shown as example. Some tools cannot be used like given in example.

In order to rectify this, a new program, website, application should be developed so that the designer/ student/ researcher use it easy and quick. Based upon the research, ideas from the authors, a new website can be developed since website will have access to the particular domains.

So, this led to the development of a navigation program named "DxS TOOL NAVIGATOR" in which process, tools and its function were shown clearly and so the user will have easier understanding, identify and use it in a better way.

DEVELOPMENT OF THE DxS TOOL NAVIGATOR

From the reference of Figure *1. The processes and sub-processes of the typical system design method adapted from MSDS (Vezzoli, Garcia, and Kohtala 2021; Vezzoli, Kohtala, and Srinivasan 2014) and MPDS (Vezzoli 2018)* a new layout is made for the **DxS TOOL NAVIGATOR** in which it helps the designers to identify, organize and use the tools according to his/her specific needs.

This tool navigator is designed for organization, identification and selection of tools that comes under appropriate design stages or processes. This process is done in the website LENS LAB POLIMI (https://www.lenslab.polimi.it/) under learning resources – tools.

Lens Lab is a research laboratory active in the design department, Politecnico di Milano for 20 years coordinated by Prof. Carlo Vezzoli. The role of the Lens lab mainly focusses on Design and System innovation on sustainability and also to educate and research to contribute to sustainable development for environmental protection, social inclusion, and economic prosperity.

It focusses on critical research and study of Design for sustainability product, process, systems etc.

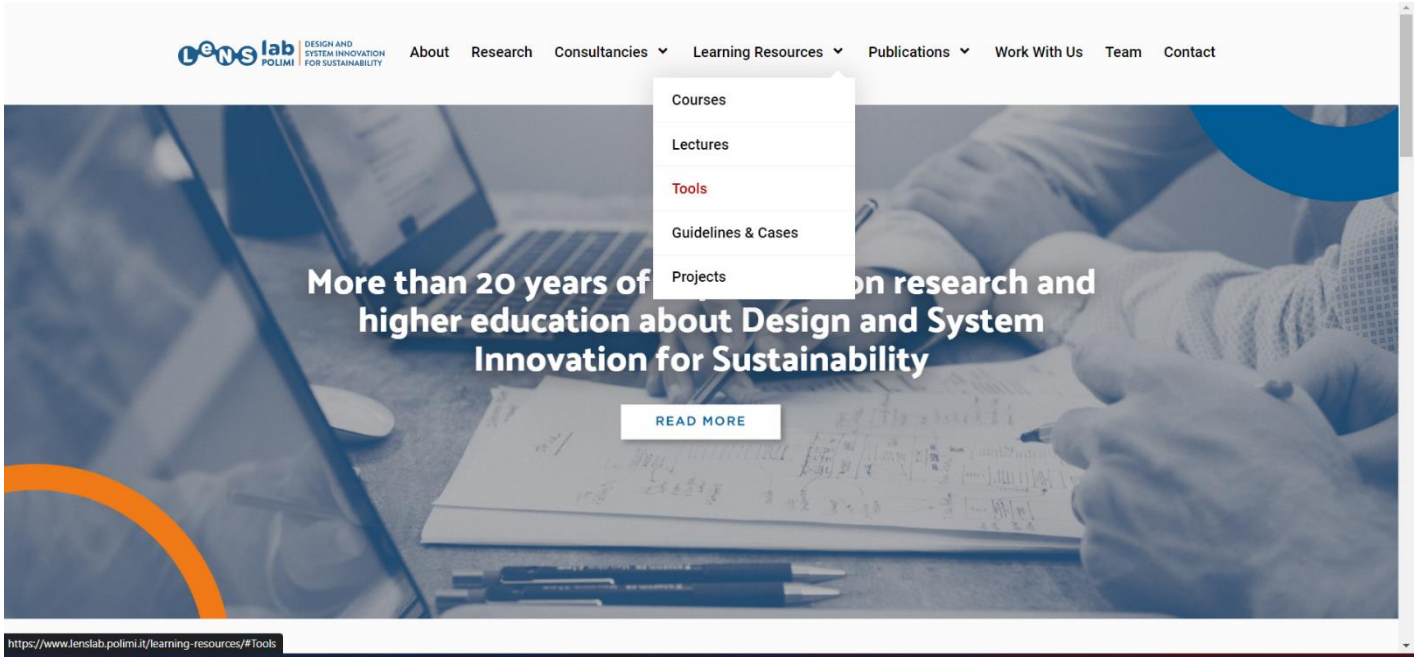

FIGURE 6 HOMEPAGE OF LENS LAB

1. Understanding the tools

- The various number of tools are classified in excel sheet with the list in a detailed format with their sources and definition about them.
- A word & excel documents of my own is created with the help of MAIN excel sheet so it can be easier to put them into the website
- Afterwards, careful characterization is made in which tools have URL SOURCES, PDF SOURCES, VIDEO LINKS and which one have NO SOURCES at all.
- Based on above information a user-friendly user interface for these tools for easy navigation across all the tools, which is made in upcoming steps.

2. Creation of intuitive UI

- A user friendly and most intuitive UI is created so that anyone can easily navigate through the tool so a manual design is made and implemented in the elementor software.
- This website is created in such a way that its easy for the designers or a user to identify and use appropriate tools for appropriate processes.

3. Layout and design

Under each category it shows the appropriate tools present in it and also demonstrates its processes, links to their particular website and if it’s an open access or pay and use. This tool navigator is done with the use of WORDPRESS and elementor.

DxS TOOL NAVIGATOR

Click over typical process of Product or PSS design for sustainability to discover available tools

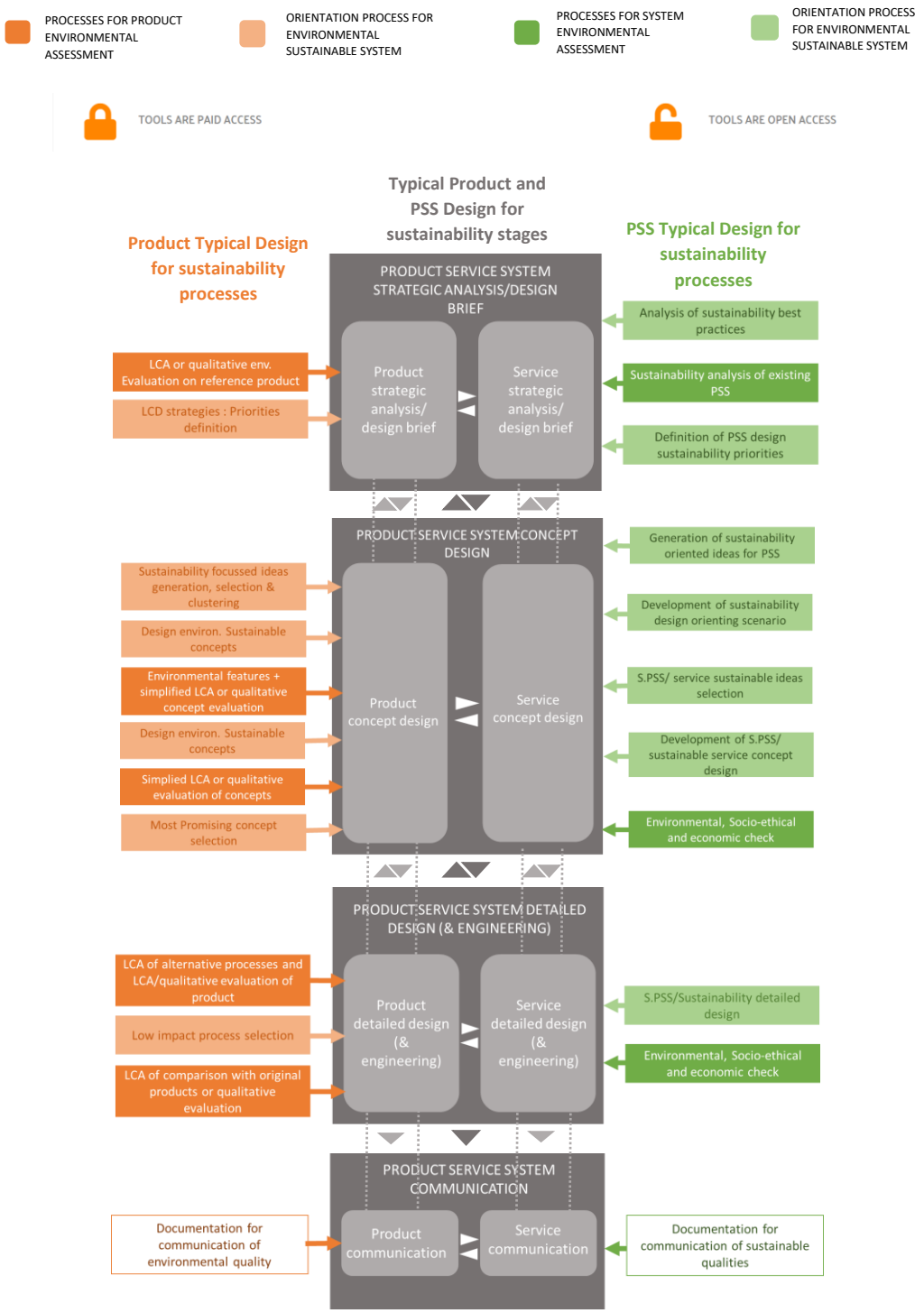

FIGURE 7 HOMEPAGE LAYOUT OF DXS TOOL NAVIGATOR

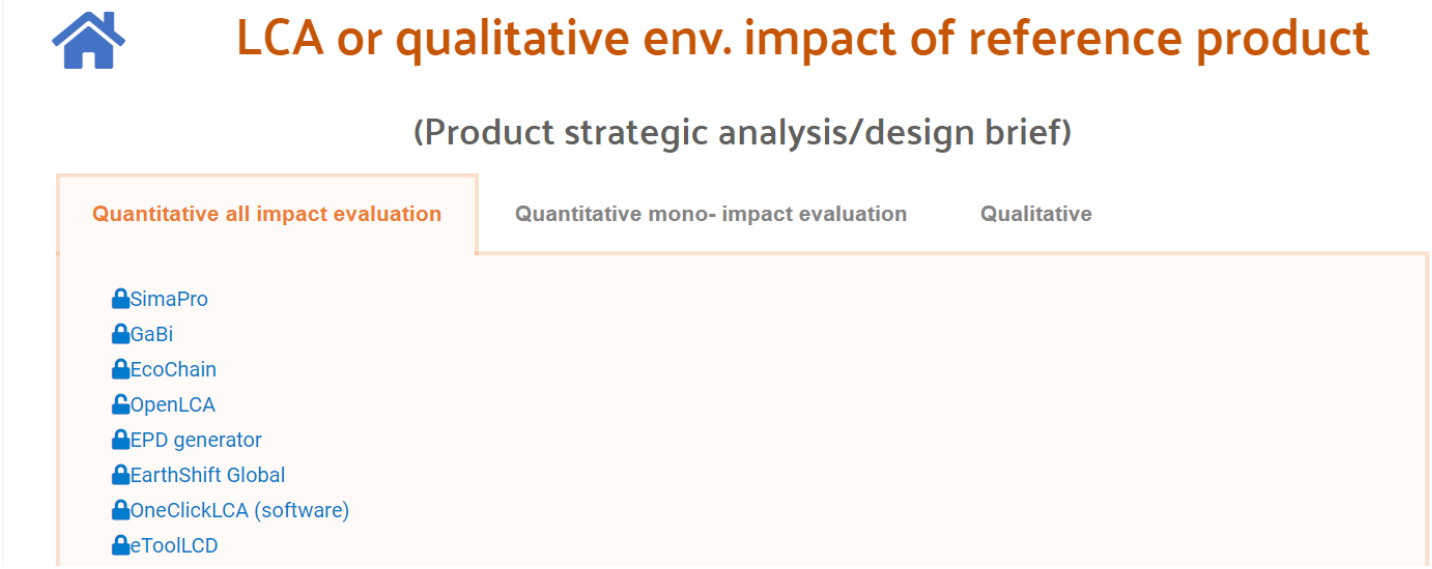

FIGURE 8 LAYOUT OF STAGE/ PROCESS TOOL PAGE

- From the figure 7, it is the main home page consisting of a layout in which all Processes are listed.
- Upon clicking any of the processes, it navigates to another page which will contain the tools which are classified according to the particular category or sub category.
- The processes are colour coded in which the user easily understands the name of the appropriate processes present
- A home icon is added in the process tool page so that the user can navigate back to the home page to make it easier for them to navigate around all tools present in the category or subcategory.

4. Developing the UI in Website

- After the Design part was done, it had to be developed in the Lens Lab website in an exact same way
- It is done by creation of blank page in wordpress and name it as “Tool Navigator” and was edited with a drag and drop page builder that was already being used in the website called “Elementor”
- Elementor is an easy to use drag & drop builder that helps in creating the design very precisely the way we want it with the help of basic HTML & CSS knowledge.

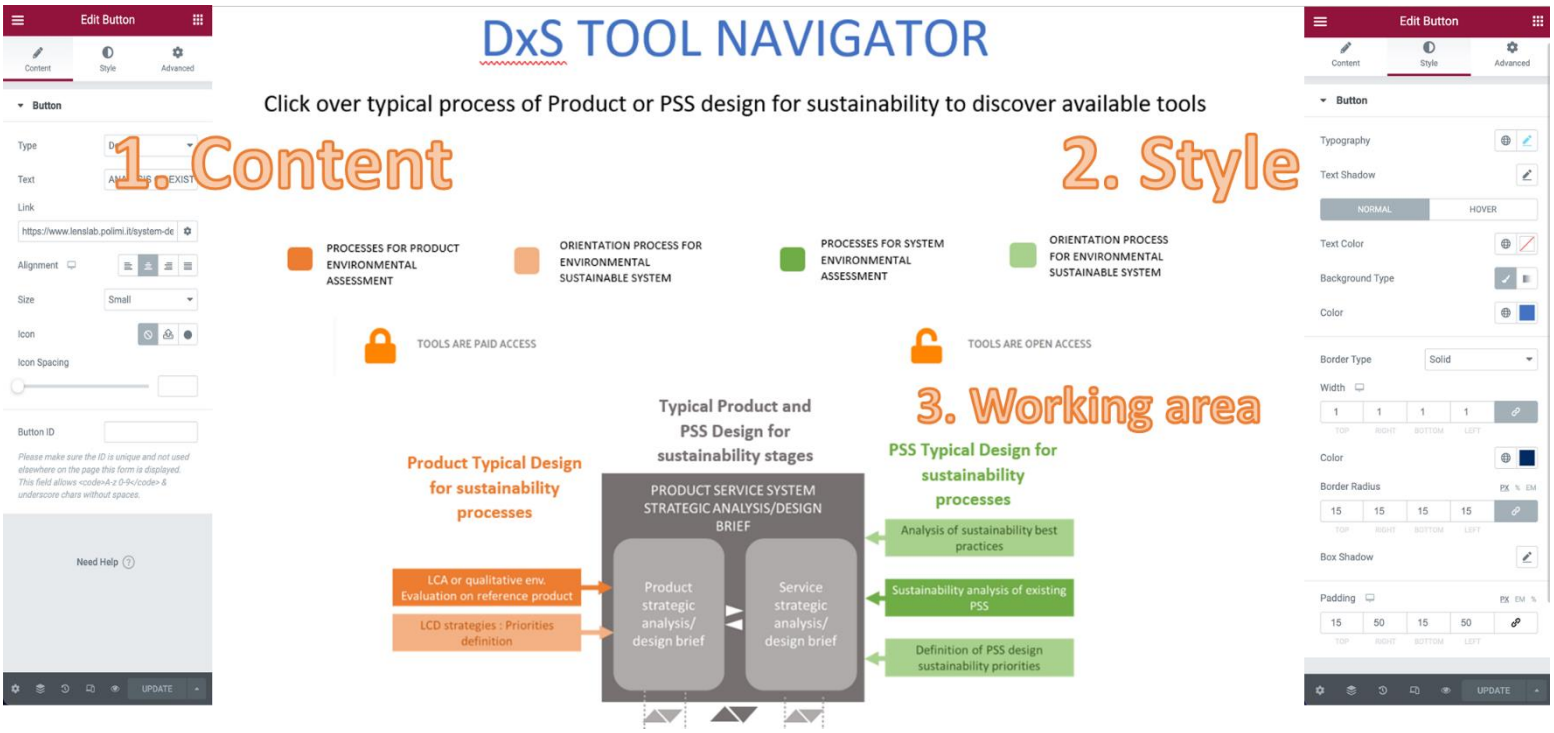

FIGURE 9 WORKING OF BUILDER

- For each and every process highlighted in blue the description is shown when navigated to the particular page as follows:

  - **Strategic analysis**: Focuses on gathering information to understand the current context and transforming the information into insights to guide the exploration of potential promising solutions.
  - **Service strategic brief**: Focuses on identifying innovative potential directions for the development of valuable solutions, using a systematic approach that considers/involves all stakeholders along the value production chain.
  - **Product and/or service concept design**: Aims to create and select the most promising product and/or service concepts.
  - **Product and/or service detailed design**: Focuses on developing the project's details to enable the implementation of the solution.
  - **Communication**: Draws up documents to report on the sustainability characteristics of the designed solution.
  - The tools that will come under specific processes and description of tool (Fig.16)

- From the figure 9, there are three parts divided: content, style and working area.

- In first and third columns multiple inner rows were added and gave them color coded dashed borders same as per own design.
- Then the buttons for navigation were added inside those inner rows as Categories & Sub-categories respectively.
- The styling to the buttons were given with different colors and paddings were inserted inside them.
- Following in the middle row the arrow icons was attached and positioned/aligned correctly to sit in the middle of each corresponding section as per position
- Finally, the bottom part was created where description of each category and different colour meant by.

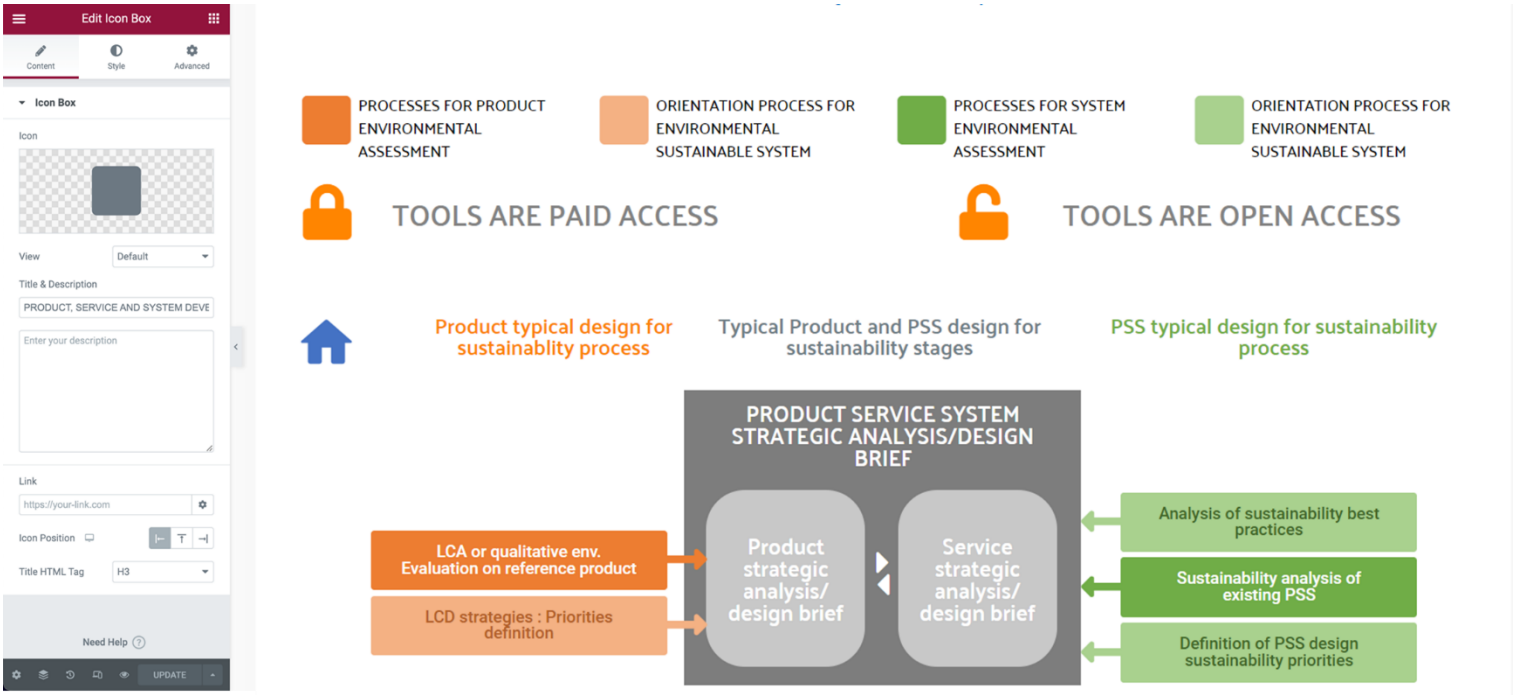

FIGURE 10 MAIN PAGE WORKING PART FOR DXS TOOL NAVIGATION

5.Development of inner tool pages

- For the creation of inner pages, an Elementor element named “TABS” were used and all the tools and their link were inserted according to the corresponding tabs in HTML code.
- A basic Cascading style sheets were added for the improvement of style, colour and texture. (fig.11)

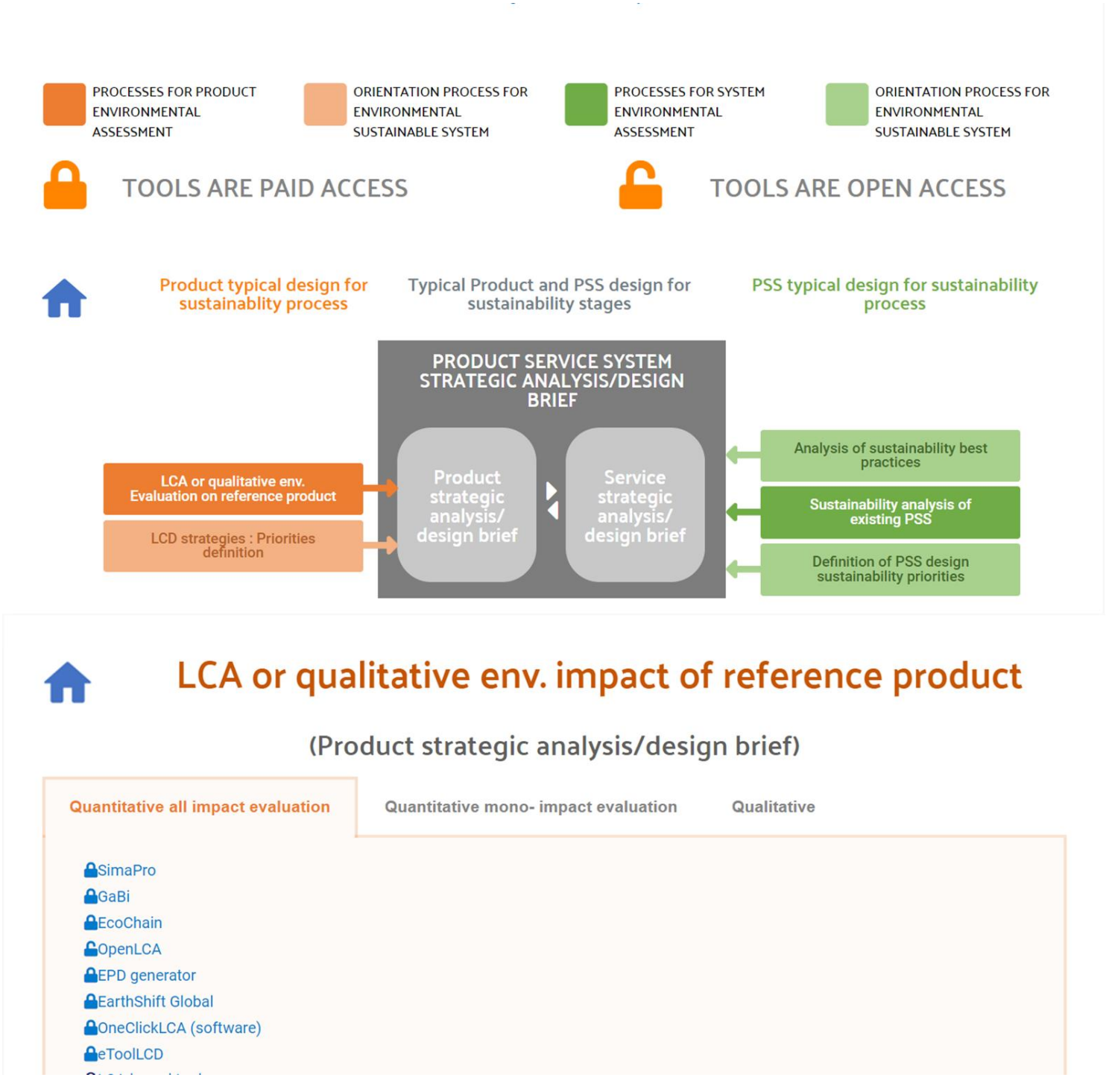

FIGURE 11 CASCADING SYSTEM STYLING OF STAGES AND PROCESS

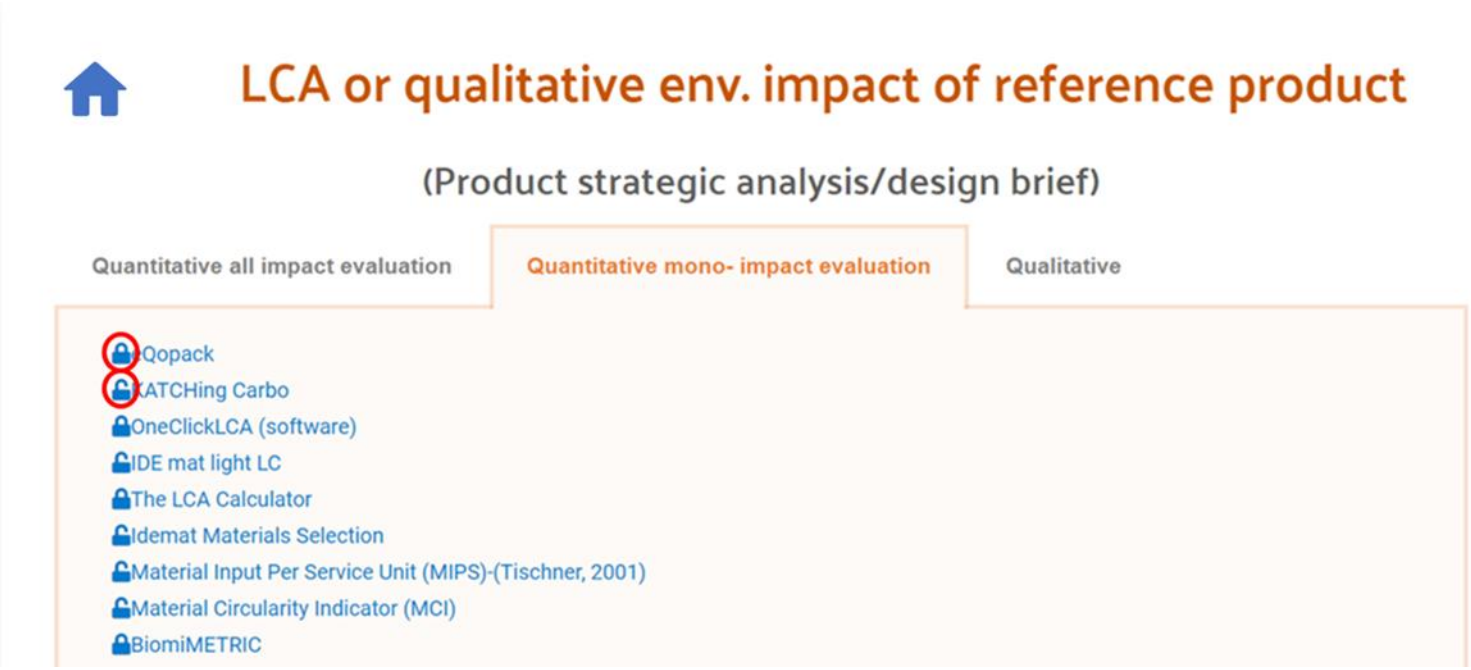

FIGURE 12 OPEN OR PAID ACCESS DEMONSTRATION

- Appropriate html code of particular's tool webpage is given in order to navigate to its particular website and in icoc command "fa-lock" or "fa unlock" is given to demonstrate whether it is a paid or open access.

FIGURE 13 HTML CODE PAGE FOR EDITING ICONS, LINKS & TEXTS

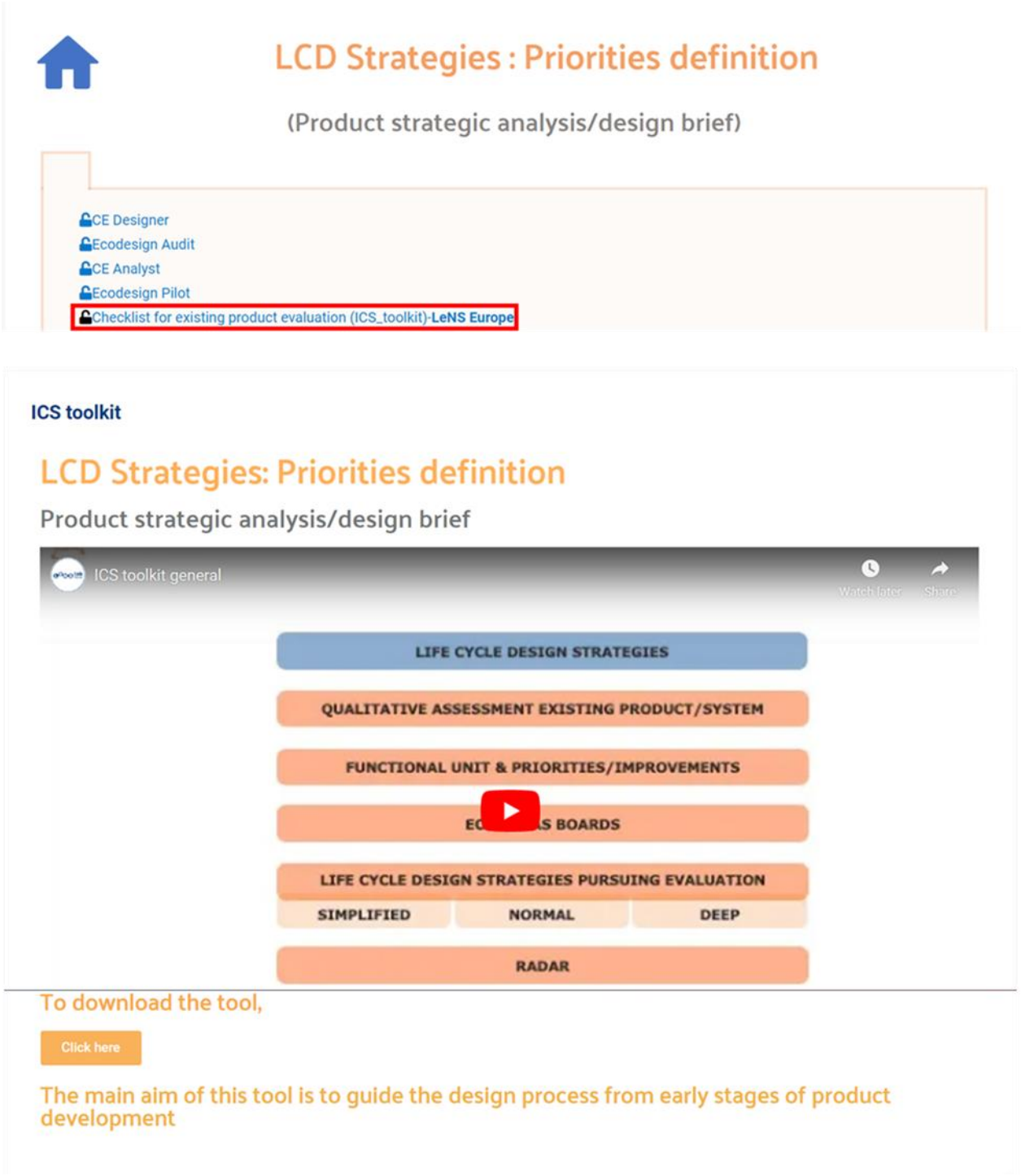

FIGURE 14 NAVIGATION TO INFORMATION ABOUT THE TOOL WHEN CLICKED

- All tool pages consist of two main things: 1) Typical development stage and processes & 2) Their particular Tools
- After creating all the Inner tools pages, each tool page was linked to the main Tool navigator page buttons one by one.
- And for the Sub-category tools buttons the anchor links were added so that whenever user clicks on them, they are directly scrolled down to that part of the page without manually scrolling down to the Sub-category tool.
- When all was done, the Main tools navigator page was attached to the “TOOLS” page on the website with the help of the button that says “START NAVIGATION”

CONCLUSION

The desk research and tool classification led in depth analysis of an overview of DfS tools, categorised by level of innovation and function. This study is summarized and further considerations were kept in mind in order to implement this in new program the tools according to the structure. The overall structure of tools that were characterized manually according to the process led to creation of program names “DxS TOOL NAVIGATOR” to make it more easier understanding

Creation of the tool navigator had been challenging part since it is created in Wordpress/ Elementor. Primary task is to characterize the tools according to its function and categories which is the hard and time-consuming part and also providing the hyperlinks to their appropriate website had been a bit difficult. Then, the characterization of open access/ Paid access was easily classified. From the designed layout of the navigator, it is easy for designers to identify and use the appropriate tools for their particular processes.

https://www.lenslab.polimi.it/tool-navigator/

The above-mentioned link is the tool navigator created under LeNS lab – Learning resources – Tools where the detailed learning about system design for sustainability and product design for sustainability is provided.

For use of designer or in an industry, this will help to adopt a suitable tool according to their projects and sustainability development.

For academic use, this research attempts to discover all DfS tools that have been present until now, to provide an overview for researchers. As far as the tool navigator concerned its easier for them to understand tools which comes under each and every process.

For educational purposes, this overview of Dfs tools and the navigator provides students on to have a deeper learning of process, subprocess and the developed tools that are characterized under it.

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