

## Design For Longevity and Design For X: Concepts, applications, and perspectives

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**Abstract**— The scientific development of Design For X is very rapid. The definition of Design For X in question is Design for specific purposes. Starting from Design For Manufacture, Design For Sustainability developed into Design For Longevity. The goal of Design For Longevity is designed to extend product lifetime. Design For Longevity is a concept where products with a short lifespan have strived for longer life. As a new concept that develops in a fast-paced era and products shift with short trends, the DFL application is indispensable. This study used a bibliometric study approach using NVIVO analysis and combined with a descriptive qualitative study of the relationship between Design For Longevity and Design For X.

**Keywords** : perceived utility, perceived ease of use, attitude toward usage, behavioral intention, and mobile banking

### I. INTRODUCTION

In principle, Design for Longevity is an effort to extend product life or lifespan [1]. This definition aims to assist product developers in actively considering product longevity when making decisions regarding product design [2]. The definition of Design for Longevity is designed that aims to design products with optimal lifetime, where optimal means considering the perspective of users, business, and resource efficiency when designing the lifetime of a product.

Cooper *et al.* (2013), estimates that product life is calculated based on the amount of use by consumers. The results of Cooper's research (2013) showed that the number of uses of knitwear was 111 times, shirts 58 times, jeans 233 times, socks 90 times, and shirts 83 times, while the average use of fashion products was 76 to 105 times. Meanwhile, research on how long fashion has been used by consumers, conducted

by Laitala dan Klepp (2020), shows that the average age of fashion products is 2.6 years. The research also shows that the total expected lifespan of fashion products is likely to be doubled to 5.2 years based on the study on (N = 46,857 garments). This estimate only includes clothing that is used by consumers of the first owner, and subsequent owners (either buying used clothing or donated clothing). Or still the first owner, but reused after being stored for a long time. The average use of fashion products in several countries includes Japan at 2.7 years, followed by the United States at 2.4 years, Germany at 2.2 years, England at 1.8 years, and China at 1.2 years [4].

In various studies on Design for Longevity, the age of fashion products has been measured by previous researchers consisting of their lifetime in units of years, the number of uses, and the number of owners until they are completely unusable and discarded. But no one has focused on Muslim fashion products yet. So that in this dissertation the focus of discussion is on Muslim women's fashion Design for Longevity. Design for Longevity itself does not only discuss fashion but also attempts to extend other types of products such as electronic products, automotive, toothpaste, smartphones, computers, Personal Computers, watches, GPS, and several other products.

New product development in the fashion sector is seen through all phases of the fashion life cycle, from production to use and disposal. Efforts to extend the life of fashion products are influenced by the early stages of new product development. Some of the efforts of fashion companies who want to extend the life of their products are by carrying out clothing take-back schemes, using recycled plastic to make new threads, using leftover fabrics, remaking discarded clothes, and increasing consumer awareness to take better care of their fashion products.

In the research previously written, one of

which was Goworek (2018), the term "Design for Longevity" was used which is relevant to extend the life of fashion. The sustainable fashion design literature proposes that designers are properly informed and able to influence the product development process. However, designers are not exclusively responsible for extending fashion products and other key business functions, including garment technology. Consumer habits in purchasing patterns, merchandising, and marketing also have an important part in extending product life.

Although the reuse of second-hand clothing or clothing persists. However, if the supply of fashion products exceeds demand and cannot be absorbed by the market, many fashion products will suffer damage. The term Design for Longevity has been used to measure the total life span of a product through fashion design and consumer behavior.

Several strategies to extend product life or Design for Longevity for fashion products had been carried out before the COVID 19 pandemic. The short life of fashion products is not because the product is damaged. Some of the reasons consumers no longer use fashion products are changes in shape, size, changes in taste, situational reasons, certain short-term fashion functions, changes in fashion or style, and other reasons [5]. So according to Laitala (2015) to design clothes so that they last longer, manufacturers must focus on material quality issues, design issues, and sizes.

For the fashion industry, 2020 was a year where things changed. Since a few years ago, fashion companies in Indonesia have been one of the largest non-oil and gas contributors to state income, during the pandemic, growth fell to minus 34.90% [6]. Consumer attitudes changed amid the pandemic, as many embraced the "less is more" or "less is more" approach which coincided with industry changes in the fashion cycle [7]. About 65 percent of consumers in a McKinsey survey conducted during the COVID-19 crisis said they plan to buy more durable, higher-quality goods, and overall, consumers find "newness" one of the least important factors. in making purchases [8].

Indonesia is also one of the countries affected by COVID-19, so many factories and physical shops for Muslim fashion are closed and their

employees are on leave [9]. During the pandemic, Muslim fashion designers relied on online sales using e-commerce platforms, websites, or social media, so they inevitably turned to customer intimacy [10].

However, the COVID 19 situation turned out to be as predicted by the British Fashion Council and the American Designers Council. In a forum it was stated that the pandemic opened up opportunities for an industrial overhaul with a slow fashion approach or a longer-lasting fashion [11]. Design for Longevity for fashion products focuses on material choices and aspects that support the longevity of fashion products [12].

Design for longevity is part of the design concept for specific purposes (Design For X). The design concept for X is a design concept according to certain needs. In some cases, the well-known design for X includes Design For Manufacturing, Design For Assembly, Design For Sustainability, and so on. In subsequent developments, the scientific theorem regarding Design for X is very broad.

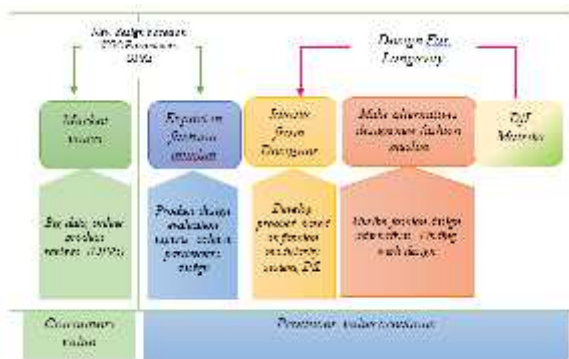
Engineering design guidelines, also known as Design For X or DfX are used by engineers to better the outcome of their design process to the X in question. For example, Design for Safety is a common DfX, used to ensure an engineer's final output minimizes the occurrence of harm to users. A potential management strategy for organizing and conveying requirements that arise from both internal operations and external supply chain partners is called Design for X (DfX).

Three main benefits can be derived from understanding how a DfX emerges: (1) identifying emerging DfXs could give engineering designers a competitive edge; (2) identifying emerging DfXs could help engineering design researchers better focus their work; and (3) engineering educators who specialize in engineering design could use this knowledge to create lesson plans and class assignments.

The Design for X"(DFX) shell is a generic framework that can be quickly and reliably customized or extended to create a range of DfX tools. The high degree of consistency and commonality among the resulting DfX tools is crucial for quick integration, trade-off analysis, and execution.

## II. METHODOLOGY

From the bibliometric mapping of Design for Longevity, the research framework for this dissertation was designed as shown in Figure 1. From the wordcloud results, consumers and designers are important factors in the success of Design for Longevity. Therefore, this research is divided into two major groups, namely consumers or consumer's value and designers from the perspective of producer's value creations.

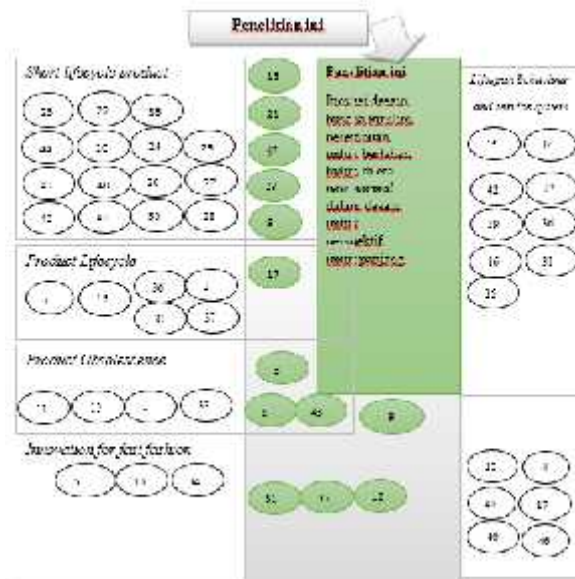


**Figure 1. Design for Longevity Research Framework for Muslim Fashion Products Case**

In the consumer area what is needed is the voice of the consumer, which is obtained from big data, and online product reviews to see what parameters are liked and disliked by consumers. Parameters obtained from the results of big data analysis are then examined and confirmed to be developed by designers and teams in the area of producer value creation. In this dissertation, the design of women's Muslim fashion products is evaluated to obtain the parameters that have the most influence on consumers. After determining the most influential parameters, the designer creates and develops the design at the idea from the design stage. Of all the stages to determine which alternative to choose, the entry into the DFL support system in this study is the DFL matrix, to find which design alternatives are feasible to produce.

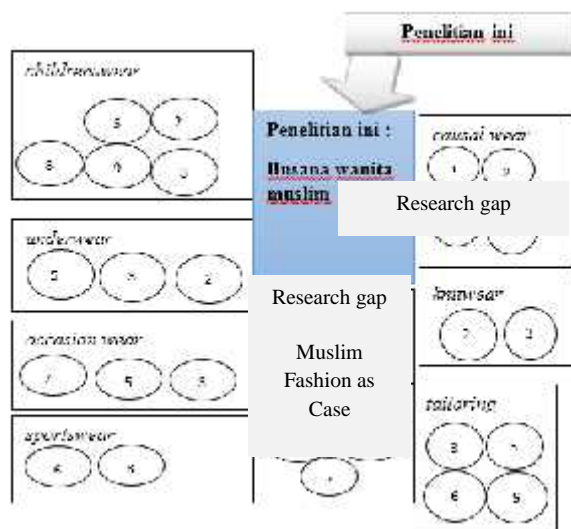
In the situation before 2015, many companies did not support the development of Design for Longevity. However, it turns out that the development of companies that support long-life products is getting higher, as can be seen in the increasing interest in research on Design for Longevity. Especially during a pandemic, consumers and producers appreciate products that can last longer.

Companies that are not affected by trends or are short-lived are companies that have a timeless fashion model or can be used for a long time, for example, a leather fashion company [13]. However, the Design for Longevity approach seems to be in contrast to fast fashion which is a short-lived fashion product. However, in reality, several fashion brands have implemented DFL and have the principle that products that last longer will be worth the investment [14].



**Figure 2. Research Areas as Case for Women's Muslim Fashion Design for Short Cycle Products in Design for Longevity**

In Figure 2, it is shown that the gap in Design for Longevity exists between several short-lived product studies, namely short life cycle products, lifetime behavior, and service systems, product life cycles, product obsolescence, innovation for fast fashion, and design for X. This research is not just built -eyes of new ideas, but the novelty of research or novelty built from several previous researchers. Figure 3 is the basic idea of novelty or state of the art from the main concept of this dissertation research. The case study raised is Muslim women's fashion, which is a separate gap from the point of view of the type of fashion studied.



**Figure 3. Research Areas Related to Types and Types of Fashion that Have Been Researched Previously**

The gap in the types of clothing studied is shown in Figure 3. Previous research examined the types of fashion for children’s wear, underwear, occasional wear, sportswear, electronic wear, denim, tailoring, knitwear, and casual wear. This type of Muslim fashion is a novelty in the case study that will be raised. Especially women's Muslim fashion. As explained in the previous chapter, the reason for conducting a study on women's Muslim fashion is that Muslims are the majority of the population, and the largest consumers in the Muslim fashion market are women [9].

Design for longevity in fashion products is a form of developing a design for specific purposes or design for X. As previously stated, Design for X (DFX), which is very well known, is designed for manufacturability, testability, installability, compliance, reliability, and other downstream factors is a crucial component of creating competitive, profitable products.

The DfX approaches demonstrate the complementary organizing principles, design for efficiency, and green design. Additionally, we group the DfX techniques based on three categories of perception 1) The scope of the product; 2) the system; and 3) the eco-system. The DfX concepts relate to efficiency in two ranges of perception: product scope and system scope. So the concept of design for longevity or

design to extend the life of a product is part of Design for Sustainability.

### III. RESULT AND DISCUSSION

The focus of this research is to fill the research gap on the previous Design for Longevity shown in the following tables:

**Table 1. Research Gap and Measured Parameters**

Component	Parameters	Wordcount
Design for Longevity	A : business	472
	B : consumer	423
	C : design	961
	D : fashion non fashion muslim	671
	E : market	441
	F : model	506
	G : process	635
	H : product	1882
	I : sustainable	873
	J : system	484
	K : value	410
	Product Development for fashion muslim based online product Review Voice of Customers validated by experts during Pandemic New Normal	GAP
	Musim fashion modularity considers parts considering size, materials, uses	GAP

The development of Muslim women's fashion products is getting faster. The COVID-19 pandemic has affected Indonesian consumers' behavior, before the pandemic and during the new normal pandemic. Before the pandemic, people tended to shop in physical stores, with complex and glamorous designs. During the pandemic and new normal, we tend to shop at online stores and demand clothes that are simpler and more comfortable.

The focus of the research gap is

- Product development for Design for Longevity taking into account online Voice of Customer product reviews validated by experts during the pandemic and new normal
- Modular Muslim fashion taking into account size, material, and usability to design extensions taking into account the fashion component taking into account size, material, and usability.

Research gaps Design for Longevity research that considers the lifespan component of fashion

products based on online Products Reviews. Following are some previous studies on Design for Longevity, using the NVivo analytical bibliometry tool. Design For Longevity and Design For X are long-lived design concepts, which can be applied to short-lived products such as fashion cases. DFL as part of perspectives

**Table 2. Design for Longevity Research Gaps Using NVivo Bibliometric Analysis**

Reference in DfL	A : business	B : consumer	C : design	D : fashion non muslim fashion	E : market	F : model	G : process	H : product	I : sustainable	J : system	K : value	GAP : Women Muslim Fashion During Pandemic	GAP. Fashion Modular
1: Files\A mixed-method study of design practices and design	3	1	36	20	0	3	7	20	40	2	0	0	0
2: Files\A new model of sustainable product development proc	0	0	18	0	2	3	3	8	3	3	9	0	0
3: Files\A survey on short life cycle time series forecasting	1	0	0	2	4	15	1	27	0	3	1	0	0
4: Files\A sustainable application based on grouping genetic alg	0	0	13	1	1	5	12	27	2	2	8	0	0
5: Files\Closed-loop supply chain management- From concept	0	9	2	1	2	0	7	8	0	4	5	0	0
6: Files\Clothing Durability Dozen Toolkit	3	13	3	2	4	2	8	13	3	3	3	0	0
7: Files\Comparisons - women ' s garments manufacturing cos	5	0	9	15	10	2	2	15	0	5	0	0	0
8: Files\Conceptualizing the circular economy- An analysis of	3	1	1	0	0	2	2	2	5	6	0	0	0
9: Files\Critical Factors Affecting Sustainable Success of Soci	0	0	0	0	1	4	6	0	1	25	1	0	0
10: Files\Design for adaptability ( DFAD )— a new concept fo	0	0	12	2	1	6	5	19	4	24	1	0	0
11: Files\Design for longevity	1	9	17	10	4	2	2	2	4	3	1	0	0
12: Files\Design for Remanufacturing - Methods and their App	2	0	25	0	1	10	14	31	1	0	2	0	0
13: Files\Design for Sustainable Mass-Customization -	2	0	63	0	13	2	35	116	23	8	11	0	0
14: Files\Design for sustainable mass-customization- Design g	2	0	63	0	13	2	35	116	23	8	11	0	0
15: Files\Design Refresh Planning Models for Manage Obsolet	1	0	19	0	0	11	0	9	0	12	2	0	0
16: Files\Developing a Decision Model of Sustainable Product	2	0	25	0	3	6	9	50	8	4	0	0	0
17: Files\Developing a Decision Model of Sustainable Product	2	0	25	0	3	6	9	50	8	4	0	0	0
18: Files\Does the effect of customer experience on customer s	0	2	2	2	5	4	4	9	5	3	9	0	0
19: Files\Eco Design and Sustainable Manufacturing in Fashion	2	2	3	10	1	0	2	15	4	1	3	0	0
20: Files\Factor affecting attitude and purchase intention of lux	1	35	2	32	24	8	3	28	2	1	16	0	0
21: Files\Fast fashion- Response to changes in the fashion indu	1	19	7	47	19	0	7	12	0	0	1	0	0
22: Files\Green Marketing - Promoting Green Consumerism fo	0	5	0	0	15	0	1	11	2	0	2	0	0
23: Files\How Big Data Analytics Boosts Organizational Perfo	4	0	2	0	1	3	4	3	5	4	3	0	0
24: Files\Limitation in large complex organizations- A case of d	0	0	4	0	1	4	7	3	0	2	1	0	0
25: Files\Impacts of sustainable value and business stewardship	13	19	0	5	9	1	0	18	19	1	15	0	0
26: Files\Inadequate Life- Evidence of Consumer Attitudes to	0	1	0	0	0	0	0	1	0	0	0	0	0

**Table 3. Design for Longevity Research Gaps Using NVivo Bibliometric Analysis (advanced)**

27: Files\Innovation for a Sustainable Fashion Industry - A De	38	21	35	33	6	26	16	53	61	22	14	0	0
28: Files\Integrating Environmental Requirements into Quality	0	0	10	0	1	1	3	17	2	2	6	0	0
29: Files\Making clothing last- A design approach for reducing	0	5	19	0	0	1	0	10	5	3	1	0	0
30: Files\Modelling environmental value - An examination of s	57	13	24	87	7	71	15	51	63	26	38	0	0
31: Files\Planned obsolescence or planned resource depletion-	0	7	11	1	0	1	6	34	4	3	0	0	0
32: Files\Remanufacturing of Short Life-cycle Products	0	1	3	1	12	4	3	29	3	1	3	0	0
33: Files\Sustainable fashion index model and its implication	0	7	3	20	1	13	1	18	35	5	12	0	0
34: Files\Sustainable Operations Management	6	2	3	0	4	0	10	18	13	1	3	0	0
35: Files\Sustainable process performance by application of Six	5	0	2	0	1	1	35	19	6	6	2	0	0
36: Files\Sustainable Production Scheduling in Open Innovatio	0	0	0	0	1	0	2	4	0	2	1	0	0
37: Files\Sustainable, smart and muslim-friendly tourist destina	0	0	0	0	5	0	0	4	2	0	0	0	0
38: Files\Technology and counterfeiting in the fashion industry	0	6	0	8	3	0	3	11	0	9	1	0	0
39: Files\Textile and Clothing Industry - An Approach towards	2	2	3	0	3	7	5	16	6	6	2	0	0
40: Files\Textile and Clothing Industry- An Approach towards	2	2	3	0	3	7	5	16	6	6	2	0	0
41: Files\The impact of covid 19 on sustainable business mode	52	1	2	3	11	26	21	3	18	6	13	0	0
42: Files\The Influence of the COVID-19 Virus on the Luxury	0	4	2	7	8	0	0	0	0	1	1	0	0
43: Files\The Waste Makers	5	6	5	2	15	0	1	23	0	2	0	0	0
44: Files\Tools for sustainable fashion design- An analysis of t	4	0	25	17	0	2	8	9	30	11	2	0	0
45: Files\Triple Helix- a sustainable economy for hijab SMEs i	9	1	3	0	2	3	0	3	5	2	0	0	0
46: Files\UNDERSTANDING An awareness guidebook guide f	10	0	0	0	0	0	7	1	0	2	3	0	0
47: Files\Will COVID-19 support the transition to a more susta	0	3	5	10	2	1	1	10	16	1	0	0	0
48: Files\Young Chinese consumers' choice between product-r	0	15	5	9	2	1	2	20	22	2	5	0	0
ANALITISAN DISERTASI YUNIA DWIE NURCAHYANIE, et al	v	v	v	v	v	v	v	v	v	v	v	v	v

Table 2 shows very clearly the position of the research gap completed in this dissertation to fill in the gaps in the research pattern on Design for

Longevity, namely discussing Muslim women's fashion and efforts to extend fashion products with modular cutting fashion.

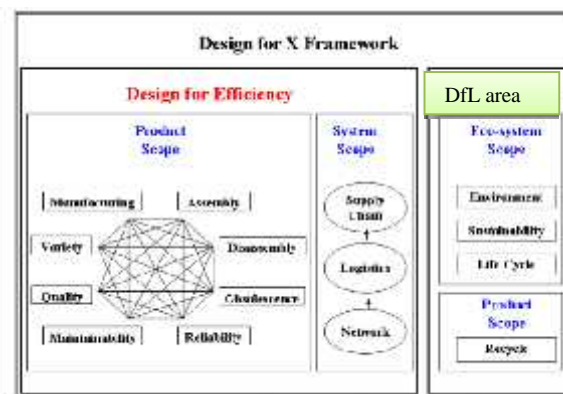


Figure 4. Framework for Design for X Perspectives

In the current era of digital technology development, the DfX theorem has undergone significant changes. Such as the application of smart design engineering: leveraging product design and development to exploit the benefits from the 4th industrial revolution DfX development as a system in 2020.

The industrial revolution 4.0 and society 5.0 era, require new products and business models adjusted to the rapidly changing market conditions, which calls for evolutions in design engineering. In this context, smart design engineering is here defined as a methodology used during the analysis and design of a product or a system, which can be composed of hardware, software, and/or services, and that Explicitly considers exploiting the technologies and opportunities from the 4th IR.

This work contributes to both design theory and practice: (i) it deepens the understanding of the necessary smart design engineering features and shows how these features impact the product design and development process as key dimensions (procedures, people, and tools); (ii) it maps the features' impact on PDDP's phases, thus providing practical directions for process improvement. To accomplish these results, a survey was performed on the initial features

presented in the literature, which helped to identify new features and to confirm their relationship to the 4th IR and their impact on the PDDP. These features were then analyzed against the 4th IR environment perspectives and core technologies, which led to an understanding of how they can be used to improve the PDDP.

The development of DfX and PDDP is inseparable from the concept of product sustainability. This is where the concept of Design For Longevity or efforts to extend product life is not only from material age, the concept of product development modularity but also from the concept of sustainability or efforts to prolong the supply chain, availability of raw materials, the readiness of the after-use process of the product itself.

#### IV. CONCLUSION

The conclusion from this article is that the development of Design For Specific Purposes or Design For X is experiencing rapid development. Starting from Design For Manufacture, up to Design For Sustainability which developed into various scientific branches. One of the scientific branches of Design For X is Design For Longevity. The purpose of Design For Longevity is various efforts to extend product life.

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