



Exploring the role of company context for informing Design for Sustainability implementation

Ali, Faheem

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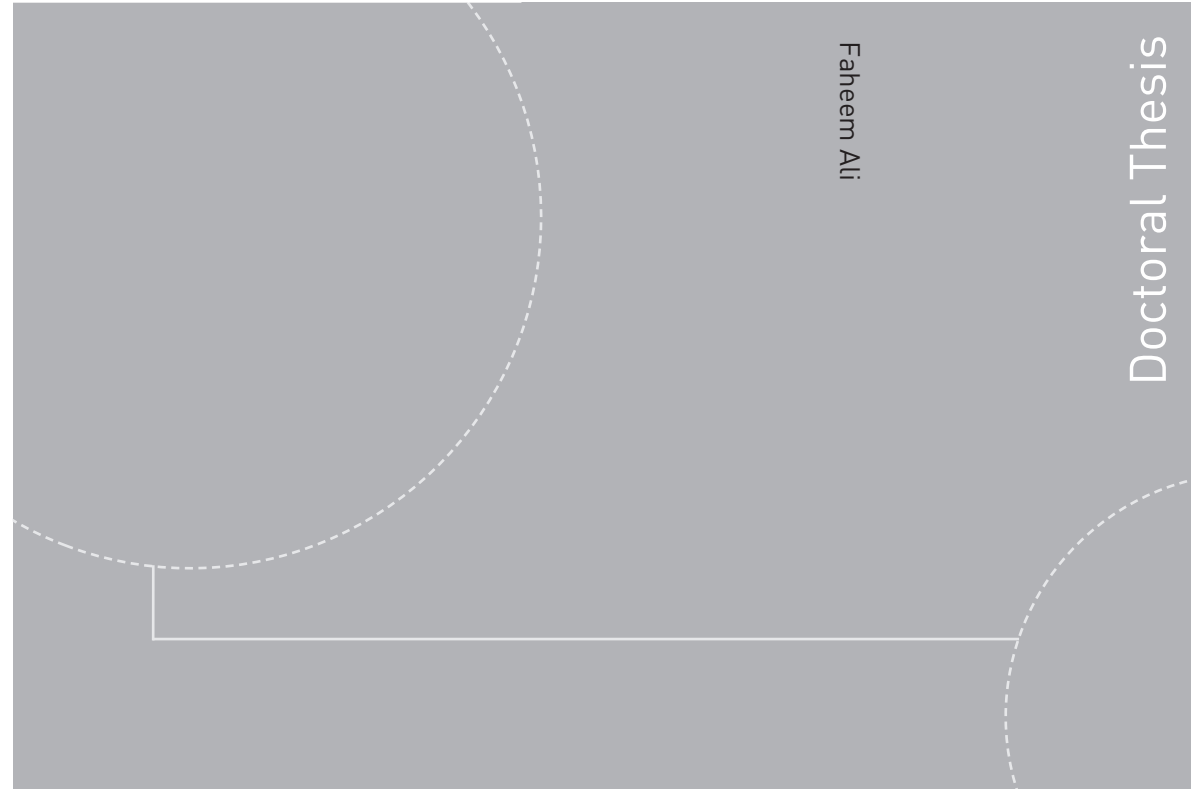
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Faheem Ali

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NTNU
Norwegian University of
Science and Technology
Faculty of Architecture and Design
Department of Design



Faheem Ali

Exploring the role of company context for informing Design for Sustainability implementation

Thesis for the degree of Philosophiae Doctor

Trondheim, August 2019

Norwegian University of Science and Technology
Faculty of Architecture and Design
Department of Design

 **NTNU**
Norwegian University of
Science and Technology

DTU Technical University
of Denmark


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If you only read the books that
everyone else is reading, you can only
think what everyone else is thinking.

Haruki Murakami
Norwegian Wood

Yesterday I was clever, so I wanted to
change the world. Today I am wise,
so I am changing myself

Jalal-u-Din Rumi

PREFACE

This PhD thesis is submitted by Faheem Ali in partial fulfilment of requirements for the Double Degree PhD project established between Department of Design (earlier Department of Product Design), NTNU - Norwegian University of Science and Technology and Division for Quantitative Sustainability Assessments (QSA), DTU - Technical University of Denmark. This PhD project is part of the Cotutelle Agreement between NTNU and DTU, involving two PhD candidates, Faheem Ali (NTNU) and Raphaëlle Stewart (DTU), who worked on two parallel tracks with mutually complementary research approaches. As part of this joint project, both Ali and Stewart have held research residencies at DTU and NTNU respectively, which jointly lasted a period of nine months. This was also followed with close collaboration through regular meetings, workshops, joint data collection and analysis throughout the three year PhD period. A total of six scientific articles were produced as part of this thesis.

Professor Casper Boks (NTNU) and Associate Professor Niki Bey (DTU) have been the supervisors in this PhD project that lasted from October 2015 to December 2018.

About me: I completed my bachelors in Mechanical Engineering from Cochin University of Science and Technology (CUSAT), India in June 2011. Thereafter in August 2013, I joined for MSc Project Management at the NTNU. Upon completion of which I was successfully selected for a 3 year PhD Scholarship at the Department of Design, Faculty of Architecture and Design (earlier with Faculty of Engineering Science and Technology), NTNU in October 2015.

ACKNOWLEDGEMENT

This PhD thesis is a culmination of a series of research steps aided and facilitated by a number of individuals who deserve a vote of thanks at this moment.

Two individuals have greatly influenced and aided the course of work I undertook during this PhD thesis, my main supervisor Casper Boks, Professor, Department of Design (ID), NTNU and Co-supervisor Niki Bey, Associate Professor, DTU. I would like to wholeheartedly thank Casper for being my guide and mentor during these three years at ID. His inputs have groomed me both as an individual and as a researcher on DfS, by both criticising and motivating me at the right times he ensured that I struck the right balance. Thank you Casper for the numerous discussions and rounds of ideation that we went through, without which this thesis would not have been possible. Further, I would like to thank Niki for his support both during the PhD project and the courses I took under his supervision. His inputs at different junctures of this thesis helped in fine tuning it. Additionally he was a great host during my residency at DTU, Denmark.

Raphaëlle Stewart, my PhD counterpart at DTU, deserves a special mention for the numerous discussions we have had during the three years. Thank you Raphaëlle for your unrelenting inspiration and inputs as we manoeuvred over different research domains.

I would also like to thank:

- Professor Tim McAloone at DTU for his valuable inputs during the PhD.
- My PhD colleagues (in alphabetic order, Abu, Carlijn, Juana, Lucy, Saara and Siti) at ID for making the PhD room jovial and lively during the three years.
- Elli Verhulst for her inputs during the framing of this PhD thesis.
- My colleagues at Quantitative Sustainability Assessments (QSA), DTU, Denmark, thank you for warmly welcoming me both the times I stayed at DTU.
- Sulalit, Sirsha and Soha for being a family far away from home.

-
- Friends and fellow cricketers at NTNUI Cricket for covering up a large a part of my social life in Trondheim and making it note worthy.
 - My sister Ajisa and brother in-law Anoop for being the extra support I very much desired so far away from home.
 - My loving brothers, Faris and Fadil for cheering me up always.
 - *Uppa* and *Umma*¹ for believing in me and supporting my decision to stay back in Trondheim to pursue a PhD.
 - My beloved wife Farsana, I have been so fortunate to have you in my life. Thank you for bearing with my odd working schedules and weekends lost for cricket, for always motivating me through the ups and downs of PhD life and lastly for bringing our lovely little Hadin into our life.

Last but not the least, praise to the eternal power I believe in for giving me the strength and motivation throughout my life and for making things easy at all challenging junctures of that journey.

¹As I call my father and mother

SUMMARY

Background: Sustainability issues on both social and environmental fronts are continuing to be a big challenge in academic and industrial circles alike. Impact of products on both the society and the environment is a research area that is being studied in this context. Researchers are increasingly focusing on mitigating sustainability challenges in the design, use and disposal phases of products, while industries are actively pursuing and adopting steps to implement sustainability initiatives in practice. Termed as Design for Sustainability (DfS), researchers acknowledge that the level of implementation of DfS in companies is not yet up to the desirable level in most industries. One of the major reasons accorded to this low/insufficient uptake of sustainability initiatives in product development stages is the lack of sufficient research focus on the human side and non-technical aspects in DfS implementation. This PhD thesis contributes to the ongoing academic discourse on addressing these in DfS implementation in companies.

Aim: This study aims at addressing the contextual factors existing within and surrounding a company that influence its DfS implementation process. The overall research question is:

How can sustainability researchers and design practitioners be assisted in understanding the context of a company better in-order to arrive at a more tailored solution to overcome DfS implementation challenges in different industries?

This overarching research question is further broken down to the following three research questions:

RQ1: What adjacent fields of research can positively contribute to the ongoing academic discussion on contextual challenges in DfS implementation?

RQ2: How do the external and internal environments of a company's organisational setting influence its internal sustainability practices and perceptions?

RQ3: How can the niche characteristics of the company be explored and understood

better to arrive at customised solutions for organisational challenges in DfS implementation?

Method: The five research perspectives presented in this thesis are based on review of extant literature, research reports and empirical data. The data set consists of interviews with seven Norwegian and Danish companies operating Fast Moving Consumer Goods (FMCG), Biotechnology, Renewable energy and Construction industries, in addition to interviews with experts in the field of sustainability implementation.

Contributions: The major contributions of this study are:

1. The potential of learning and adapting insights from alternate research fields to improve DfS implementation processes in companies is scientifically presented. Five different well established research fields are explored and their relevance established backed by empirical data and extant literature.
2. The importance of understanding company context in DfS implementation scenarios is studied and presented within the ambit of established design methodologies and management frameworks.
3. Solutions to help sustainability researchers, practitioners and consultants to better understand the company context and thereby take a customised approach suitable for each company involved in DfS projects.
4. Empirically rich and qualitatively in-depth data on companies which are often found lacking in current literature.

Further to this, the scientific dissemination done as part of this PhD thesis consists of 3 journal papers, 4 conference papers and 4 posters (one best poster award).

Conclusion: Companies are evidently different from each other in perception, preparedness and accommodating change in their daily routines. These factors are influenced by its context which has been to a large extent ignored by the mainstream research on DfS topics. The insights presented from five different perspectives covered in this thesis help in establishing the importance of company context and potential ways to factor in the context in a DfS implementation scenario. It is increasingly important for designers, academicians and consultants to be aware of these existing company characteristics and to respond to it with due importance. DfS tools (such as LCA, Checklists, Guidelines, tools to evaluate environmental impacts of raw material used) are necessarily a strong aid in this process but certainly not sufficient enough to meet the sustainability goals of the company as long as the tools do not consider the human side aspects of the company.

Research on sustainability topics will have at the least a sustained and increasing focus even in the near future. With increased awareness and greatly accepted initiatives such as the UN Sustainable Development Goals (UNSDG) creating more ground for discussion and application of research, this thesis contributes to furthering the overall steps taken by academia on DfS topics. The research perspectives of this study primarily help in opening up the research window to hitherto less explored research fields such as user personas and management theories.

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ABBREVIATIONS

DfS	=	Design for Sustainability
DfE	=	Design for Environment
EHS	=	Environment, Health and Safety
LCA	=	Life Cycle Analysis
NGO	=	Non-Governmental Organisation
PMBok	=	Project Management Book of Knowledge
PD	=	Product Development
PM	=	Project Management
PDP	=	Product Development Process
PS	=	Product Sustainability
PSS	=	Product Service Systems
SDG	=	Sustainable Development Goals
SME	=	Small and Medium Scale Enterprises

Part I

Thesis

INTRODUCTION

The world is increasingly acknowledging the fact that the current trend of consumption and material usage cannot be sustained for a longer period of time. Increasing global trade and ever growing pressure on the earth's resources have made sustainability a prime area of concern in all businesses alike. The global population currently uses resources that far exceed the limits and capabilities of our planet, thus creating an unsustainable future for the coming generations (WWF, 2014). This trend had set off discussions in both academic and industrial circles resulting in steps taken to act on the increasingly challenging environmental issues and it continues to be on the forefront of ongoing research work on sustainable businesses around the globe.

The 17 United Nations Sustainability Development Goals (UNSDG), specifically Goal 12 on Responsible Consumption and Production, further adds to this discourse on the response required from both industry and academic research to act upon these sustainability challenges in product development. As a result, the recent decades have seen an increasing interest from the academia in integrating sustainability in the product development phase (Ceschin and Gaziulusoy, 2016; Tukker et al., 2001). The scientific efforts to integrate sustainability topics in the product development phase has seen a series of terminologies being used in academic literature such as *Eco-design*, *Design for Environment (DfE)*, *Environmentally Conscious Design* (Brezet and Van Hemel, 1997). The more recent entrant to the list has been *Design for Sustainability (DfS)* which incorporates the social and economic aspects of the product in addition to the environmental aspects that were otherwise focused on by eco-design researchers. Researchers have proposed numerous tools, methods and approaches to overcome the challenges associated with DfS implementation in companies (Pigosso et al., 2015). Even though these tools and methods have greatly contributed to solving the technical challenges in product development processes, these tools are not yet widely used by the industry or deliver the desired results as envisaged by the tool developers (Bey et al., 2013). A primary reason for this has been associated with the strong focus of eco-design tools and methods on the technical aspects of the products while ignoring the relevance of the company's soft factors such as managerial topics, skill levels in the company and communication (Johansson, 2002) between departments on

sustainability topics. Earlier researchers have acknowledged this gap in DfS implementation research and have taken a shift in focus towards more organisational aspects of the companies involved in DfS projects (Hemel and Cramer, 2002; Tukker et al., 2001). Even though several companies have made use of results emanating from such research and have successfully embarked on the sustainability journey, the number of companies still remain to be small (Hallstedt et al., 2010). One of the major challenge in this process has been the different contexts of the companies involved in sustainability that DfS implementation literature has failed to address to a large extent. Hence, it is this need to focus on the context of the company that forms the basis of this PhD thesis.

1.1 What is Design for Sustainability?

1.1.1 Defining “Design for Sustainability”

Eco-design has been often used in the context of environmentally conscious product design and it focuses on minimising the environmental impact of the product from raw material extraction to final disposal (Boks and McAloone, 2009; Ceschin and Gaziulusoy, 2016; Pigosso et al., 2015). As opposed to this, *Design for Sustainability (DfS)*, an oft recurring phrase in this PhD thesis, is a broader term encompassing social and economic aspects in addition to the environmental issues relating to life cycle of the product. Hence, it is imperative to define *DfS* for the readers to understand the discussion that follows in the subsequent chapters of this thesis. This thesis uses the United Nations Environmental Programme (UNEP) definition for *Design for Sustainability*

as a profit driven strategy in which companies work globally, including the more limited concept of Eco-design, to improve efficiencies, product quality and market opportunities (local and export) while simultaneously improving environmental performance.(Programme and Technology, 2006)

Additionally, this thesis deals with implementation of DfS in companies. I have used the Oxford dictionary definition for implementation, which is, *the process of putting a decision or plan into effect; execution (“Implementation”)*. Thus in the context of this thesis, any plan, process and action undertaken to realise sustainability goals in designing of products of services in a company.

1.1.2 Gap in DfS implementation

DfS implementation in companies has been receiving increased attention in academic literature in recent years. As mentioned earlier, authors have proposed tools, methods and approaches to streamline and guide the DfS implementation process in companies. However, a review of these tools and methods points towards low level of usage (Bey et al., 2013) of these in industries. Further, studies also identify major barriers and challenges to DfS implementation in companies (Baumann et al., 2002; Boks, 2006; Dangelico and Pujari, 2010; Stevels, 2007). More recent papers on the topic also observe the same trend in DfS challenges (Dekoninck et al., 2016; Pigosso et al., 2013; Ramani et al., 2010). Some of these earlier works stress upon the need to consider the human side aspects

in organisations implementing DfS strategies and undertaking DfS projects (Boks, 2006; Brones et al., 2017; Verhulst and Boks, 2012).

Further, studies also argue that success of sustainability implementation in companies varies based on the context and capabilities of the company. These include factual aspects, such as size, industry branch, geographic location, and history of the company. In addition, DfS implementation may be affected by a multitude of factors existing within and beyond the company boundary. These could include for example the place in the hierarchy of the supply chain (Bey et al., 2013), which affects the potential to collaborate and negotiate up and down the supply chain and with other partners such as knowledge organisations. This will affect access to both human, financial and physical resources. Further, organisational culture may also affect DfS implementation project (Johansson, 2002). The internal factors could include the way DfS is communicated, empowerment and involvement, resistance to change, the commitment towards sustainability, differences in expectations from the project outcome by different departments and stakeholders involved, the prioritisation of DfS projects within the overall company portfolio, overall strategy and long term vision of the top management etc. The maturity level related to experience in dealing with DfS implementation will also determine how DfS is materialised in practice (Pigosso, 2012). The existence of a wide variety of contexts makes it likely that successful DfS implementation will have to take this into account, and that prescribing ‘off the shelf’ approaches that do not take into account the variety of contexts will essentially be meaningless. Thus, it is interesting to draw parallels and draw inspiration from studies in adjacent literature that take into consideration the context of implementation, best practices for overcoming similar challenges in other managerial study areas or cultural underpinnings that bear an impact on the context of the company.

With this preliminary assumption, this PhD thesis attempts to identify how the context of companies may be understood better in-order to have an informed DfS implementation process in companies. To inform this process, I have taken insights from existing literature in academic fields that I have identified to be relevant in a DfS implementation context, conducted case company interviews in companies having a DfS project, interviews with sustainability experts; and explored how these can contribute to such a discussion. Additionally, an in depth analysis of existing literature has been carried out to identify the different contextual aspects of DfS implementation in companies and how it may impact the success or failure of the DfS project. This includes the organisational management perspectives for DfS implementation in companies, an exploration of regional characteristics of organisations and other organisational interactions. Thus this thesis is an attempt to take these discussions on the role of human side factors of organisations in DfS implementation further. Section 1.2 explains further the research objective and research questions formulated to address this research gap.

1.2 Research Objective and Questions

Following the observations outlined in Section 1.1 the main objective of this thesis was to explore how the context of a company can be understood to have an informed DfS implementation process. In order to operationalise this objective the following main research questions was formulated:

How can sustainability researchers and design practitioners be assisted in understanding the context of a company better in-order to arrive at a more tailored solution to overcome DfS implementation challenges in different industries?

This overarching research question was further broken down into three sub-research questions to answer it better and are as following:

RQ1: What adjacent fields of research can positively contribute to the ongoing academic discussion on contextual challenges in DfS implementation?

RQ2: How do the external and internal environments of a company's organisational setting influence its internal sustainability practices and perceptions?

RQ3: How can the niche characteristics of the company be explored and understood better to arrive at customised solutions for organisational challenges in DfS implementation?

The link between these research questions and publications arising from this thesis is illustrated in Figure 1.1. The research questions are revisited in Section 5.1 to provide the answers emanating from this thesis.

1.3 Guide to reading this thesis

This thesis is presented as a collection of articles compiled in a chapter based manner aimed at answering the research questions mentioned in Section 1.2. The thesis is mainly divided into two parts. Part I consists of the main report which present in a coherent manner, the major activities carried out as part of this PhD and the results emanating from it. Certain sections of this thesis are curated from the publications produced as part of this PhD project, this is mentioned in the beginning of all such sections wherever applicable. Part II consists of publications arising from this PhD. Part I is further divided into five chapters:

- **Chapter 1** introduces the topic of Design for Sustainability (DfS), the research background, research gap the thesis is addressing and the research questions that are being answered in this thesis.
- **Chapter 2** elaborates on the theoretical background of this thesis. The chapter details on the relevant academic discussions hitherto carried out on DfS implementation and establishes the theoretical footing for succeeding chapters.
- **Chapter 3** presents the overview of the project, the research design and the research methodology used in curating this PhD project.
- **Chapter 4** presents the results from five different research perspectives taken in this PhD project to answer the research questions.
- **Chapter 5** discusses the results and findings of this thesis and its contribution to the ongoing academic discussion on DfS implementation. And concludes the thesis by summarising the major contributions of this PhD project work, identified limitations and potential future work.

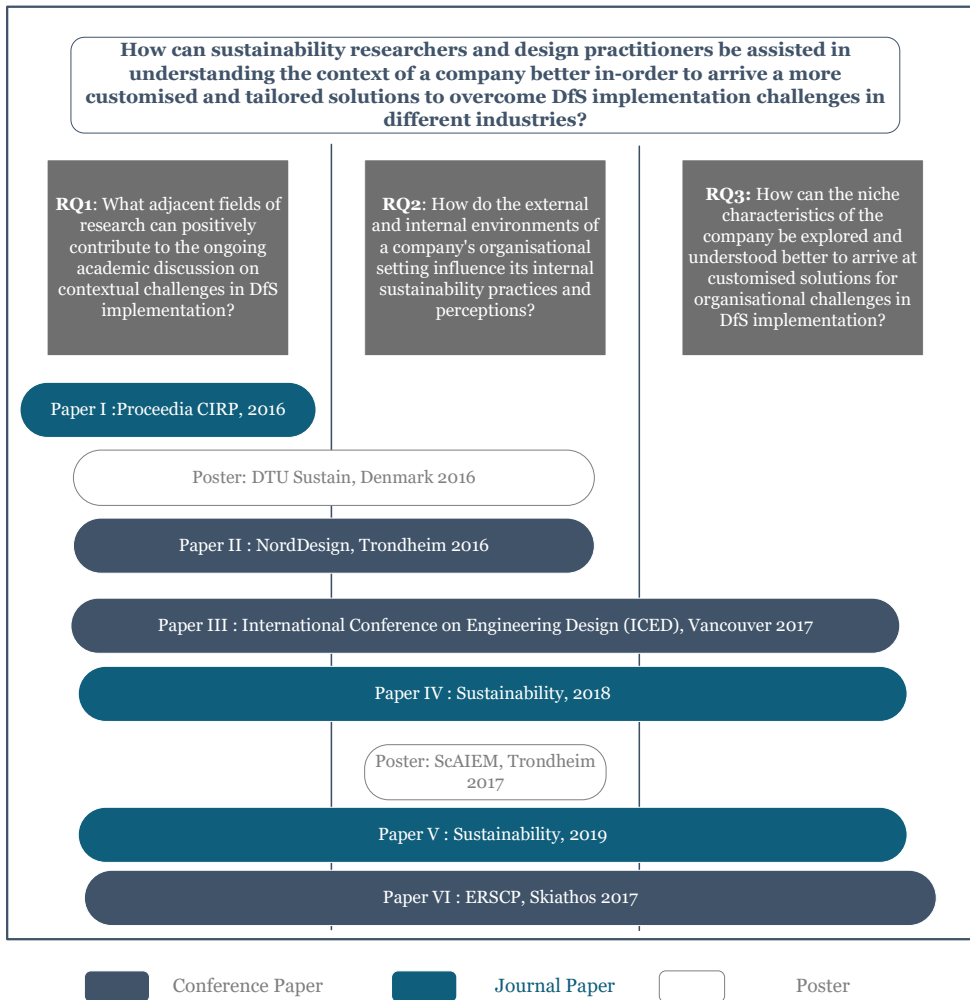


Figure 1.1: Research Questions linked to publications arising from this thesis

1.4 Overview of the Project

1.4.1 Scientific activities carried out as part of this project

This PhD project is a culmination of a multitude of scientific activities involving research stays, course work, conferences, workshops and seminars. An overview of this is provided in Figure 1.2 (Inspired from Daae, 2014)

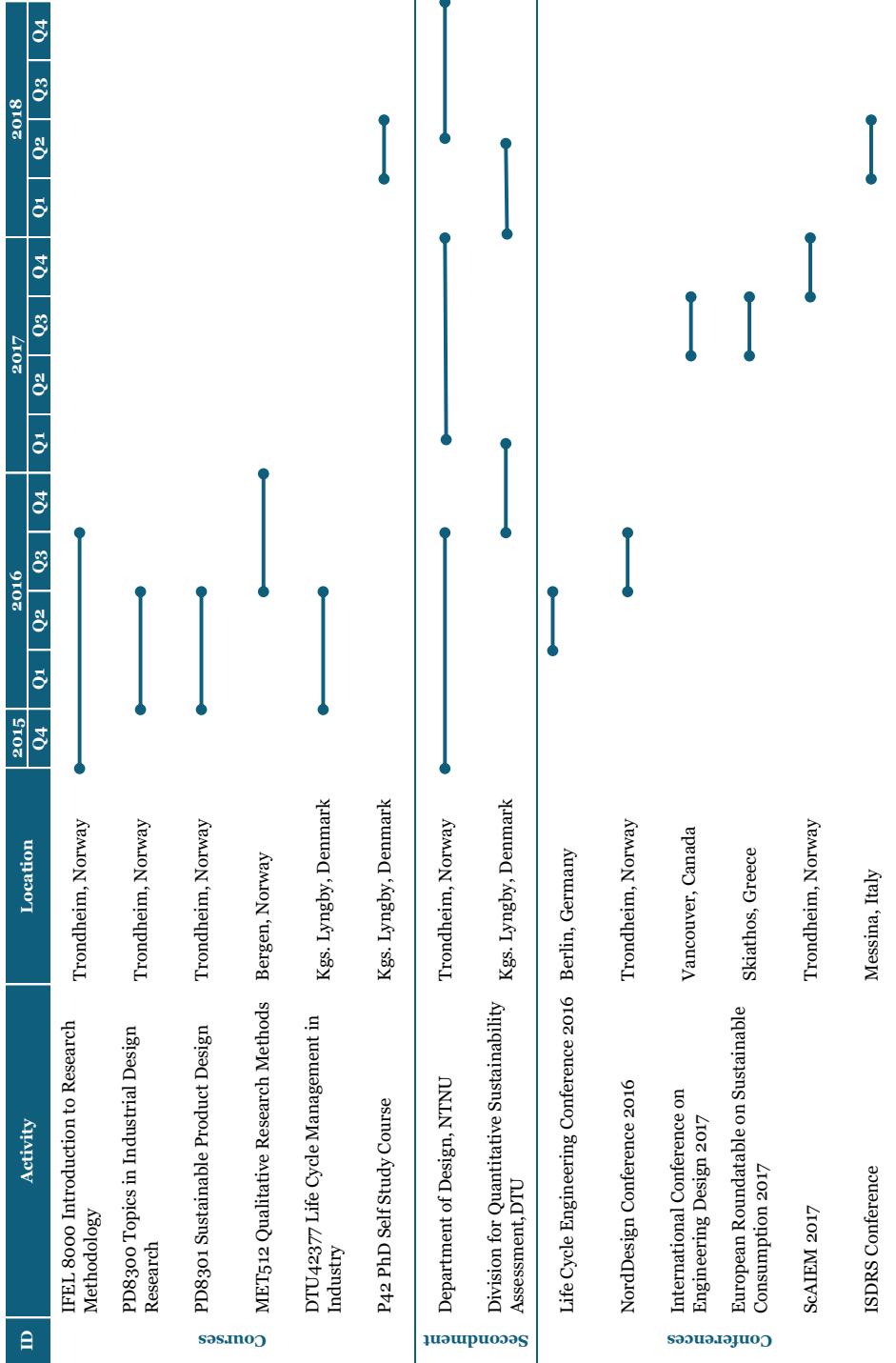


Figure 1.2: Overview of different activities done as part of the PhD

1.4.2 Publications arising from this PhD

- Paper I** Faheem Ali, Casper Boks, and Niki Bey (2016a). “Design for Sustainability and Project Management Literature A Review”. In: *Procedia CIRP* 48, pp. 28–33. ISSN: 2212-8271. DOI: 10.1016/j.procir.2016.04.185
- Paper II** Faheem Ali, Elli Verhulst, and Casper Boks (2016b). “The ‘Nordic Approach’ and how it may support design for sustainability”. In: *Proceedings of NordDesign*. NordDesign 2016. Vol. 1. Trondheim, p. 10. ISBN: 978-1-904670-80-3
- Paper III** Faheem Ali, Casper Boks, and Niki Bey (2017). “An exploration of company personas to support customized DfS implementation”. In: *DS 87-5 Proceedings of the 21st International Conference on Engineering Design (ICED 17) Vol 5: Design for X, Design to X, Vancouver, Canada, 21-25.08. 2017*. International Conference on Engineering Design (ICED) 2017. Vancouver: The Design Society, pp. 385–394
- Paper IV** Faheem Ali, Raphaelle Stewart, Casper Boks, and Niki Bey (2019). “Exploring Company Personas for Informing Design for Sustainability Implementation in Companies”. In: *Sustainability* 11.2, p. 30. ISSN: 2071-1050. DOI: 10.3390/su11020463
- Paper V** Raphaelle Stewart, Faheem Ali, Casper Boks, and Niki Bey (2018). “Architect, Catalyst, Advocate, and Prophet: A Four-Lens View of Companies to Support Ecodesign Integration”. In: *Sustainability* 10.10, p. 3432. ISSN: 2071-1050. DOI: 10.3390/su10103432
- Paper VI** Faheem Ali and Casper Boks (2017). “Internal company collaborations and its impact on Design for Sustainability implementation in companies”. In: *Proceedings of ERSCP 2017*. European Roundtable on Sustainable Consumption and Production. Vol. 18. Skiathos, Greece: ERSCP Society, p. 8

THEORY

This chapter presents the theoretical background of this thesis. As explained in Chapter 1, DfS implementation forms the theoretical underpinning of this thesis and following subsections present the State of the Art in DfS implementation literature, the various approaches that have been taken to improve DfS implementation in companies and conclude by establishing the importance of understanding the company context in DfS implementation.

2.1 Design for Sustainability

The topic of sustainability considerations in product development has undergone a series of changes ever since its origin as a product development process focused on minimising waste during the production phase, termed as “end-of-pipe” (Bhamra, 2007). The focus then gradually shifted to the use phase of the product and further to closing the material loop through recycling or reusing the product (Ceschin and Gaziulusoy, 2016). This transition has been assisted by the academia and consultants through tool development (Baumann et al., 2002), discussion on the organisational factors that influence DfS implementation (Hemel and Cramer, 2002) and by identifying the various enablers and challenges in sustainable product development (Alblas et al., 2014; Bey et al., 2013; Johansson, 2002). To a large extent this discussion has revolved around developing tools, methods and frameworks in-order to help companies make sustainable choices in product development phase (Pigosso et al., 2015).

In an earlier study on the presence of eco-design in consumer electronics, Li et al. (2015) distinguish between applied and theoretical focus on sustainability in product development, while the theoretical part of sustainable design was established earlier than the applied part, these two have evolved and closely interacted with each other. Theoretical eco-design has been characterised by concept development, methodologies and principles whereas, the applied stream has consisted of business integration in companies and tool and method development in academia. This evolution of eco-design stream is illustrated

in Figure 2.1. As can be seen, the initial stages of sustainable design focused on the environmental impact of the product and ways to reduce it. This further evolved to include environmental management systems, green design initiatives and recycling and reuse of production waste internally and externally. As mentioned earlier, this transition has been ably supported by the academia through research focusing on solving the technical challenges involved in designing sustainable products.

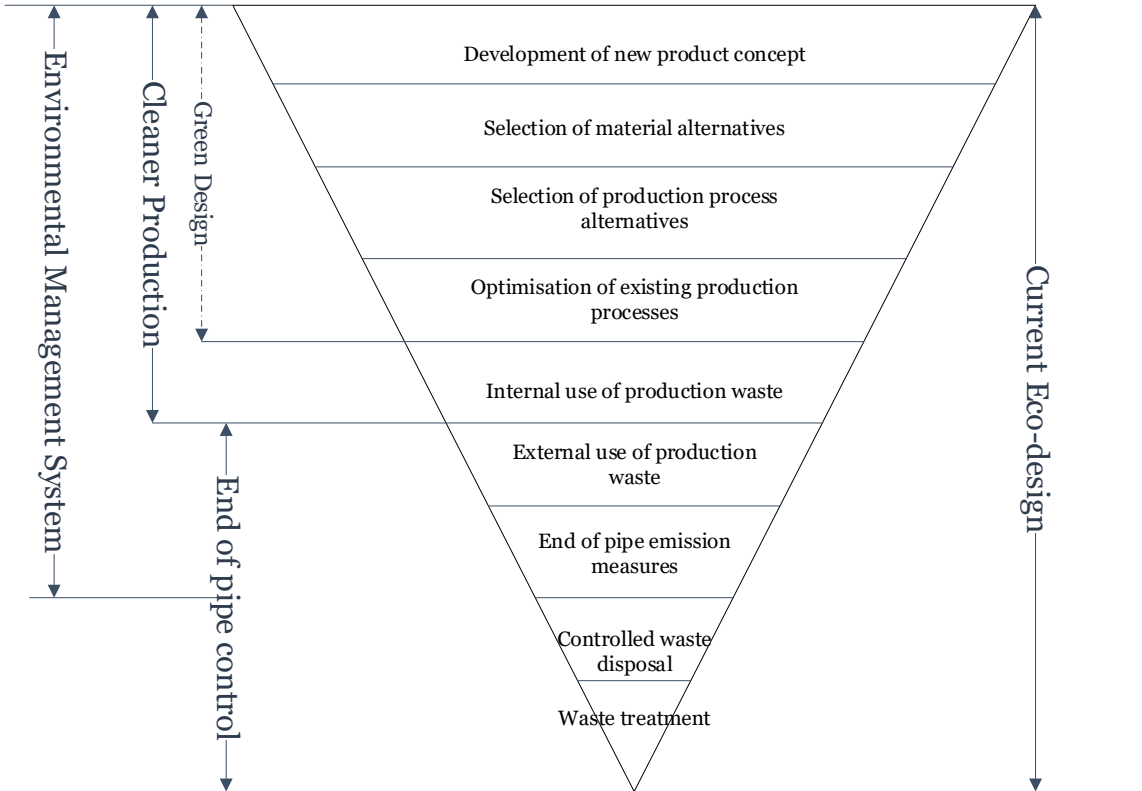


Figure 2.1: Evolution of the concept of Eco-design (Adapted from Li et al., 2015)

Exploring the evolution of DfS in a quasi-chronological pattern, Ceschin and Gaziulusoy (2016) present four different stages through which the topic of DfS has evolved. These stages are namely, Product, Product-Service System (PSS), Spatio-Social and Socio-Technical System. Product innovation level focused on improving the environmental performance of the products and introducing new products. PSS, took this further in presenting products as services that involved evolution of new business models (Bocken et al., 2014). The third stage of innovation level shifted the focus towards the spatio-social conditions of human settlements such as neighbourhoods and cities. The final and current stage of Socio-technical level considers the impact of design on a complete systems level and how transitions can be supported at this level. Further, Ceschin and Gaziulusoy, 2016 present an evolutionary framework (shown in Figure 2.2) that map the different academic contributions that address these stages. As can be seen from the framework, the focus

on the human aspects and the organisational context of DfS are more recent entrants in both academic research on DfS and industrial applications. Thus underlining the basic premise of this thesis, i.e the context and human side of DfS implementation. Boks and McAlone (2009) indicate a similar transition in eco-design research along two spectra, one from a strictly environmental focus to sustainability perspective. The second taking a bigger system perspective to the topic of sustainability in eco-design and extending its boundary from company or product specific to entire value chain and product system.

In a similar yet more recent study on the evolution of research on product sustainability (PS), Dyllick and Rost (2017) categorise the evolution stages into three, namely, 1.0, 2.0 and 3.0. The initial evolution level categorised PS initiatives as a shift from selective improvements of the products to holistic improvements encompassing the product life cycle. Thus shifting the focus from linear cradle-to-grave model to closed circular loop of product development that addresses the triple bottom line of sustainability. Phase 2 according to Dyllick and Rost (ibid.), shifts the focus from better products to good products as efforts to mitigate the negative impacts of products were no longer sufficient to combat the damage caused on the living environment. Thus necessitating a shift towards PS that also increased its positive impact on the environment. Phase 2 also signalled the need for radical improvements on the sustainability performance of the products in comparison the hitherto incremental improvements. In the third and final phase of PS evolution, Dyllick and Rost (ibid.) observe the gradual movement from private value to public value where the products are intended to contribute to the overall societal value rather than just the customer using the product. An illustration of this typology of PS evolution is shown in Figure 2.3. The conceptual study concludes by observing that the progress made in PS research through different interventions including DfS has not been successful as intended due to certain commonly observed obstacles in the implementation process, mainly accompanying trade-offs in sustainability focussed projects. Nevertheless, change towards creating positive impacts using products has a great potential in inspiring companies, organisations and other stakeholders in PS implementation, concludes Dyllick and Rost (ibid.). The following subsections of this Chapter explore factors in the context of DfS implementation in companies in detail.

2.2 The role of context

Management studies have commonly acknowledged the business advantage involved in having more sustainability focused business strategies (Porter and Kramer, 2011). Thereby, implementing sustainable design in companies has been influenced by a multitude of factors both internal and external to the companies (Bey et al., 2013). Researchers have explored these different drivers that necessitate or facilitate companies in moving towards more sustainable solutions in their offerings. Compliance with legal requirements, market forces in the form of alternate products, customer demand and company image/fear of bad publicity have been some of the external drivers for companies (Bey et al., 2013; Tukker et al., 2001). Further, companies were found to have different motivational factors based on their business size; micro companies found cost-reduction, marketing and brand value associated with DfS as a driver; customer demand and brand value were found to be relevant in SMEs.

In order to systematically explore this relevance of understanding the company context

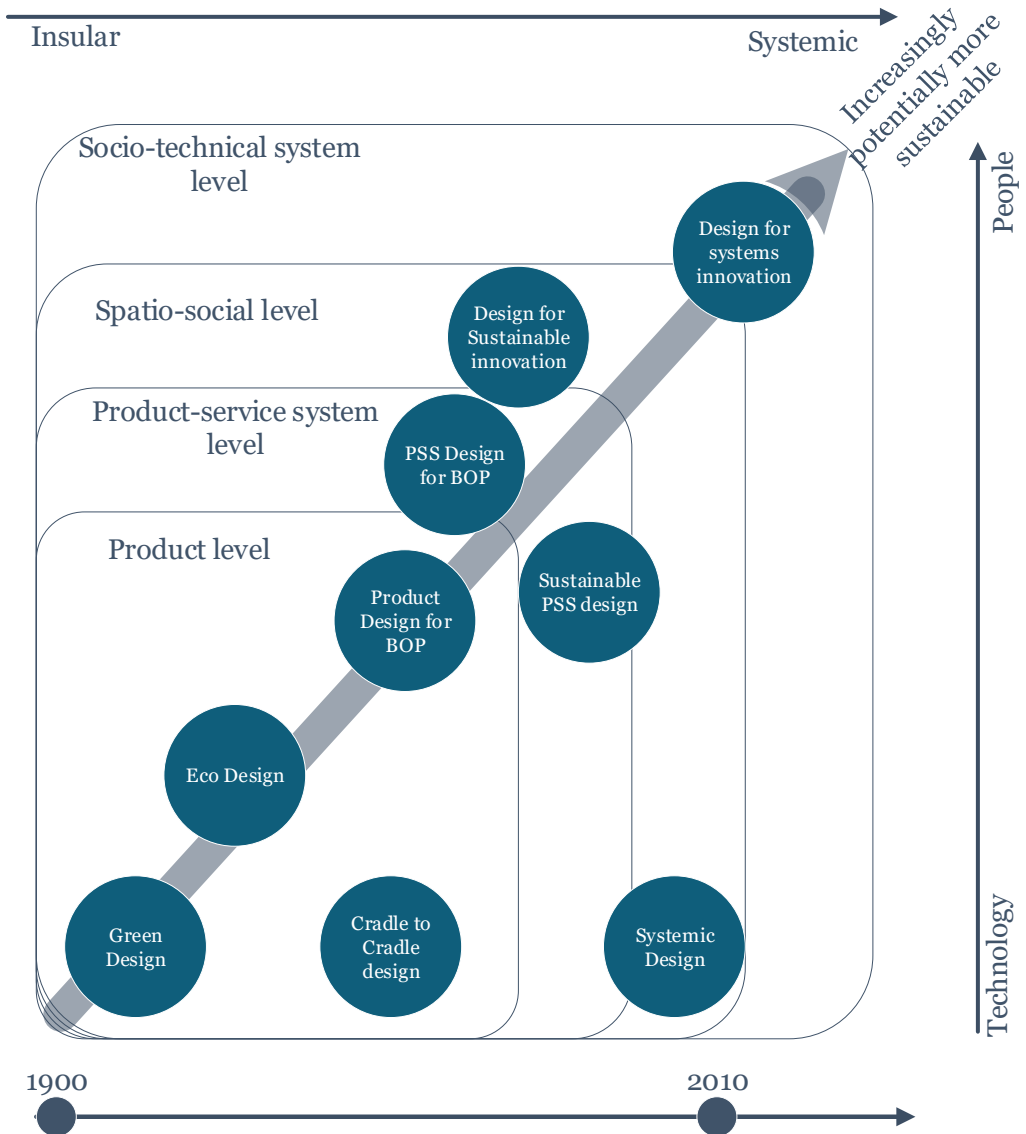


Figure 2.2: The DfS Evolutionary Framework with different DfS approaches mapped onto it. BOP = Bottom of Pyramid, PSS = Product Service Systems (Adapted from Ceschin and Gaziulusoy, 2016)

in better informing DfS implementation process, a literature review of research articles pertaining to this topic was carried out. A general observation in the 25 reviewed papers showed a trend of discussion on company context under two major categories, namely, management practices in DfS and operationalising DfS. As can be seen from Table 2.1, management practices include issues that are relevant both from a tactical and decision



Figure 2.3: Typology of Product Sustainability Evolution (Adapted from Dyllick and Rost, 2017)

making process for the company, while the second category of operationalising DfS covers contextual factors of the company concerned with realising the sustainability goals during the implementation phase. This includes the non-technical aspects involved in Product Development Process (PDP) such as familiarity of the members with DfS concepts, tools and methods available to the company, compliance requirements for specific products among others. The findings under each category are summarised in the following subsections. For the purpose of comprehensive analysis and to ensure the inclusion of relevant articles, the literature search for the purpose of compiling Table 2.1 included empirical studies focusing on eco-design implementation, integration of sustainability concerns in PDP, environmental sustainability in product, and product life cycle management studies in specific industries (eg. electronics, furniture).

2.2.1 Management Practices in DfS

As mentioned earlier, the management practices outlined in the following subsections pertain to actions within companies that include the decision making processes, strategic thinking and managerial approach to sustainability. Among the reviewed articles six general themes could be identified under the management practices in DfS. The findings under these six different categories are further discussed below.

Market Conditions

A commonly identified factor in DfS implementation has been the market conditions existing around the company (Boks, 2006). Market conditions could include the presence of demand from customers for more sustainable products, availability of suppliers capable of providing required raw material for such products among others. Bey et al. (2013) and Alblas et al. (2014) observe that the right demand for products act as a facilitator in implementing DfS in companies. Further, companies are increasingly facing documentation requests from customers and other stakeholders on sustainability (Bonou et al., 2016;

Poulikidou et al., 2014; Prendeville et al., 2017). Researchers also observe that companies can find it challenging to match the customer demands with the in-house potential in companies with regards to product development in DfS (Dekoninck et al., 2016).

Strategic Focus

Overall company level strategies that set the mission and vision of the companies have been found to have a strong role in defining the different pathways companies take in integrating sustainability into their activities. Policy and strategic vision reflected in the company documents and within the company's activities are strong drivers in this process (Poulikidou et al., 2014). The rational decision making in product development is often driven by the overarching strategies on the product portfolios (Bonou et al., 2016) and the shared mission and vision is a significant reason for supporting DfS implementation (Hallstedt et al., 2013). Further, companies stress upon the need for a well supporting business case when embarking on the sustainability journey (Boks, 2006; Deutz et al., 2013; Domingo et al., 2015).

Senior Management

The role of senior management in supporting sustainability focussed projects in companies has been widely acknowledged in literature. Doppelt (2003) identifies seven major sustainability blunders done by companies and of them is the false sense of security a rigid management structure provides to its employees. Companies having such a rigid management structure often leaves less room for innovation for their employees, while innovation is an integral part of DfS (Ceschin and Gaziulusoy, 2016). A consistent feedback on DfS projects during usual review meetings (Bonou et al., 2016) and steps to systematically engage the senior management in the decision making process over voluntary contributions (Domingo et al., 2015; Poulikidou et al., 2014) have been found to drive the implementation process in the empirical studies that were reviewed. Hallstedt et al. (2010) opine that eco-design projects are often complex due to multitude of factors and a strong commitment from the management is often helpful in mitigating the complexities in the implementation process.

Communication

DfS projects often involve a larger group of actors than conventional projects due to the increased number of parameters to be considered during the PDP. There are also increased chances of encountering conflicts and need for making trade-offs during project implementation (Byggeth and Hochschorner, 2006). Subsequently, necessitating a clear and continuous flow of information to keep the relevant stakeholders updated. Doppelt (2003) observe that progress of sustainability initiatives will stall without consistent exchange of clear information within the company. Further, Boks (2006) highlights the importance of having a two way communication on eco-design topics in opposition to the conventional top-down directives. A holistic approach to informing all the concerned stakeholders in DfS projects is needed (Poulikidou et al., 2014) to ensure that the sustainability advisers in the company are sensitive to the perceptions of other employees

in the company (Bonou et al., 2016). Thereby avoiding conflicts and mis-communication during the implementation process.

Collaboration with stakeholders

As observed in the preceding sub-section, communication with relevant stakeholders is an important aspect of DfS implementation as observed from the reviewed literature. This also follows the observation that sustainability focussed product development often requires the involvement of multiple actors, such as suppliers, customers, competitors and external agencies that contribute to the development process. A significant amount of the literature reviewed highlighted the importance of collaboration practices in realising the goals in DfS projects. Prendeville et al. (2017) observe that collaboration with external experts in the field is a great learning opportunity in ecodesign focussed NPDs. Collaboration practices in DfS should therefore invite perspectives from both internal and external to the company (Skelton et al., 2016) as it helps in effectively integration DfS within the PDP (Dekoninck et al., 2016). Further, industrial studies show that engaging external partners improve the feasibility of such projects (Alblas et al., 2014; Bonou et al., 2016; Brones and Monteiro De Carvalho, 2015; Hallstedt et al., 2013).

Organisational Culture

The influence of cultural setting on the functioning of organisations is a well addressed research topic in business and organisational studies (Hofstede, 1980). The literature review also revealed a similar trend while considering management practices in DfS implementation and organisational culture existing within the company. Researchers have identified the need for a transversal approach to DfS implementation taking into consideration the cultural and human aspects existing in the company (Brones and Monteiro De Carvalho, 2015; Verhulst and Boks, 2014). Individuals in companies will have a sense of reception or resistance towards sustainability topics owing to their perception of sustainability.

2.2.2 Operationalising DfS

The actual implementation phase in DfS projects in companies are governed by factors such as the skill and knowledge the company holds on the topics, access and applicability of various available eco-design tools, the level of formalisation in implementing sustainability among others. The literature reviewed for the purpose of this thesis revealed a set of factors in the company context that influenced the operationalisation of DfS activities in the company. These factors are discussed in the following sections.

Targets and KPIs

The effectiveness of DfS initiatives are often governed by the presence of predefined targets and KPIs with regards to the sustainability performance of the company and the products being developed. Companies that defined Environmental KPIs (eKPI) were found to be effective in creating awareness and thereby ensure participation of internal stakeholders in

PDP (Bonou et al., 2016). Such targets and KPIs are further more effective when defined by taking into consideration the value generation offered by the products. This inculcates an innovation driven environment for product developers and engineers involved in the process (Skelton et al., 2016). Researchers observe that the lack of clarity in goal setting on sustainability topics can often to lead to lack lustre results (Alblas et al., 2014) and create barriers in the overall implementation process (Boks, 2006).

Sustainability Institutionalisation

The level of formalisation in DfS implementation process is a very commonly addressed topic by researchers in the field. Academic work has tried to contribute to this discourse in the form of management frameworks, eco-design tools, checklists, stage gate models and industrial best practices for sustainable product development (Brones and Monteiro De Carvalho, 2015; Deutz et al., 2013; Verhulst and Boks, 2012). As can be observed from Table 2.1, this was a commonly mentioned topic in the reviewed literature as well. Hallstedt et al. (2013) and Alblas et al. (2014) observe that there is a strong need to integrate sustainability in companies in a structured manner. This level of formalisation can be materialised in both top-down and bottom-up manner as suitable to the company context (Brones and Monteiro De Carvalho, 2015). Further, the initial learning from eco-design projects can be formalised for uptake in future projects (Prendeville et al., 2017) and thereby avoid dependence on individual eco-champions driving the DfS process in companies (Boks, 2006). Domingo et al. (2015), Doppelt (2003), and Johansson (2002) observe that the level of formalisation has a positive impact on the success and efficiency of DfS projects.

DfS Tool usage

Research on DfS/Eco-design tool has been a topic of interests for academicians and industries for a considerable part of the evolution on the topic (Boks and McAloone, 2009). As stated earlier, even though there is an abundance of eco-design tools available in market, their uptake is often low and the ones currently in use do not always deliver the desired results (Pigosso et al., 2015). A major reason for this is the lack of adaptability and ability of these tools to engage different actors involved in DfS implementation process (Brones et al., 2017). Challenges in finding the right tool and developing the skill sets to use it has been another long standing observation among researchers (Bonou et al., 2016; Dekoninck et al., 2016; Skelton et al., 2016). A few others have observed that tool deployment does not always result in better results (Alblas et al., 2014) due to the resulting resource wastage arising from poor coordination in tool usage and acceptance of it (Johansson and Magnusson, 2006; Poulidikidou et al., 2014).

Knowledge and skill requirement

Integrating sustainability in the product development process requires a multidisciplinary approach due to the different stakeholders involved and additional information (on environmental and social parameters) required in comparison to the conventional product development process (Johansson, 2002). One of the major challenges with this is the need

for new skills and knowledge for designers and product developers working on sustainability topics. Employees need to understand the environmental impact of their firm's activities in order to take ownership and partake in the process (Alblas et al., 2014; Bey et al., 2013; Deutz et al., 2013). This know-how helps the stakeholders in lowering uncertainty surrounding their responsibilities (Bonou et al., 2016) and choose the right tools (Hallstedt et al., 2013) among others. Researchers observe that companies can create this required skill sets through regular cross-departmental teaching and training activities (Domingo et al., 2015; Poulikidou et al., 2014), and sustaining it through rewarding feedback and encourage continuous learning practices (Doppelt, 2003; Verhulst and Boks, 2012).

Compliance Culture

Legal regulations and compliance measures are another set of factors that drive companies into taking up DfS in their product development practices. While larger corporates/macro companies had the fear of economic sanctions and legal compliance as the major external drivers (Santolaria et al., 2011). The company size was found to influence the compliance requirements by companies. Larger companies were expected to have more compliance requirements and more likelihood of doing it so compared to smaller or medium scale companies (Deutz et al., 2013). Companies also tend to identify and prioritise on legislation that could act as business drivers in sustainability implementation, such as the possibilities of exploring new market segments or additional customer base that can be catered to with sustainable products (Bey et al., 2013; Domingo et al., 2015).

Alignment of needs and expectations

Companies comprise of separate departments, team and individuals, and are thereby expected to have different backgrounds and expertise in PD projects. These differences can lead to different expectations and motivational factors among employees. The perceived lack of immediate benefits from sustainability initiatives (Santolaria et al., 2011), lack of prioritisation and individual collective interest (Brones et al., 2017) and incompatibility between goals of the company and sustainability issues (Prendeville et al., 2017) are some of the commonly identified obstacles. Researchers identify the need to create a common understanding on sustainability issues, strategic alignment with overall goals, early integration of sustainability in PDP and structural realignment in organisations (Hallstedt et al., 2013; Johansson and Magnusson, 2006; Verhulst and Boks, 2014) to meet the new demands arising from DfS projects as some of the steps to overcome these issues.

Article	Source of Data	Management Practices in DIS				Operationalising DIS				Alignment of needs and expectations		
		Market Conditions	Strategic Focus	Senior Management	Communication	Collaboration with stakeholders	Organisational Culture	Targets and KPIs	Sustainability Institutionalisation		DIS Tool usage	Knowledge and skill requirement
Brones et al. (2017)	Literature Review and Action Research	-	Need to define and update the long term ambition of environmental targets in the organisation	-	-	Engage/influence the different groups involved in the PPP	-	Formalise plans for progressing towards a higher integration of environmental sustainability	Adapt and experiment tools to company environment, while engaging actors	Build necessary capacity in terms of knowledge and skills in the company	-	Classical barriers such as prioritisation, individual and collective interests are also prominent in DIS
Prendeville et al. (2017)	Action Research	Customer requests can initiate eco-design process in companies	Business context and strategy are critical for national design approach	-	-	Partnerships with external experts are great source for learning eco-design NPDs	Initial learnings from NPDs are gradually internalised in companies to formalise the process	Formalised PPP and product development facilitate mutual engagement between actors in DIS	Multiple evaluation indicators and review criteria needed	-	-	Incompatibility between goals of the company lead to some frictions or exclusive projects
Skelton et al. (2016)	Case Study	-	-	-	Environmental specialists and eco-champions play central roles in integrating eco-design	DIS projects should include unfulfilled needs and value generation for engineers that motivate them to participate	Formalised PPP and product development facilitate mutual engagement between actors in DIS	Brokers for DIS should have skills to adapt tools to specific needs of the companies for better adoption boundaries	-	-	-	A common understanding on the level of sustainability desired and responsibilities surrounding it should be made
Dekoninck et al. (2016)	Literature Review and Survey	Matching customer requirements with DFS aspects can be a challenge	Need for long term sustainability strategy and follow up on the status	-	Need to raise awareness surrounding sustainability within and beyond the company	-	-	Tool integration continues to be a challenge in DIS	Lack of familiarity on DIS terminology and knowledge is challenging	-	-	Role of resistance from departments in integrating DIS in PD
Bonou et al. (2016)	Action Research	Sophisticated customer requests on environmental data is an emergent external driver	Absence of overarching portfolio strategies can hinder effective integration of DIS	Management attention in a project is crucial to DIS implementation	Environmental specialists should remain sensitive to project perspectives while communicating on DIS	Engaging relevant stakeholders will increase the feasibility of DIS projects	Formalisation is a necessary but not sufficient condition for realising DIS goals	Ease of comprehension and level on existing tools determine the application of successful DIS tools	Knowledge about existing products lowers awareness on making effective application of eKPIs	-	-	DIS initiatives should be aligned with overall PIM for easy integration
Domingo et al. (2015)	Action Research	Need for eco-design feasibility study and communication throughout the value chain	Strategies should be progressive and in tune with overall company objective	Plans to move from voluntary to compulsory contributions from management	Communicate and create awareness throughout the company business issues is required	Value chain focussed knowledge building on DIS issues is required	Functional requirements of DIS affects its efficiency in PD	-	Ensure cross-departmental teaching and training initiatives	-	-	Identify and prioritise the legislative requirements on DIS that can be business drivers

Table 2.1: Relevance of company context as identified from DIS literature

Article	Management Practices in DfS				Operationalising DfS			Alignment of needs and expectations				
	Source of Data	Market Conditions	Strategic Focus	Senior Management	Communication	Collaboration with stakeholders	Organisational Culture		Targets and KPIs	Sustainability Institutionalisation	DfS Tool usage	Knowledge and skill requirement
Brones et al. (2015)	Literature Review	-	Need for strategic and corporate objectives as guiding tools for internal company goals	-	-	A multistakeholder approach should be taken in DfS projects, inviting insights from different actors	Need for a transversal approach taking into consideration the human factor, culture and approach to DfS	-	A systemic approach should be taken converging both bottom up and top down movements in integrating sustainability	Eco-design tool customisation should be emphasised taking into consideration the culture and PDP in company	-	Alignment and insertion of environmental focus in PDP early to ensure focus in decisive stages
(Alex) Abbas et al. (2014)	Interviews with Workshops	Customer demand for sustainable products increases	Sustainability focus on strategies to meet the needs of the company	-	-	Continuation of practices along the supply chain for DfS implementation	Map sense of reception towards sustainability among employees	Need for clearer scope and targets on sustainability	Structured process management practices needed	Tool deployment alone does not translate to better results	Clarity needed in identifying and creating the impact of DfS activities	Extent of environmental regulations determine how companies approach DfS
Poullikidou et al. (2014)	Interviews	Sustainability documentation is increasingly being requested by customers	Policy and strategy on sustainability are strong drivers	Need to ensure harmonised and standardised DfS processes across the organisation	Holistic communication on DfS to the company	Need of external networks and information flow to influence external actors	Personal motivation of employees is needed to ensure better performance	-	Influence of organisational size and tradition on practices	Resource wastage due to lack of coordination in tool usage and availability	Need for regularity in education programmes on DfS	Regulations influence the decisions companies make
Brones et al. (2014)	Case Study	Portfolio and sales influence environmental requirements in products	The gap between actual implementation and strategy of the company poses challenges in PDP	Environmental issues create an additional workload which needs to be streamlined by management	-	Extending the sustainability vision to the supply chain and managing trade-offs is challenging	-	-	Integration of sustainability in the company's activities and PDP framework has a positive influence	-	PD teams express lesser concern on DfS issues as they have little knowledge on the topics	There is need for more realistic and achievable environmental goals to ensure participation
Verhulst and Boks (2014)	Case Study	-	Individual initiatives on DfS can lead to development of vision, mission and strategy that is crucial to the overall firm	Need for top management to take more responsibilities in order to strengthen the impact of DfS activities	-	Use of ambassadors in organisation is a good way to spread information on sustainability issues	-	-	Checklists and tools are considered as a secondary support to an existing process on DfS issues	Training on sustainability issues is solicited in most companies as the field requires new skills	-	Assigning clear duties and responsibilities to individuals provides a feeling of empowerment
Bay et al. (2013)	Survey and Workshops	Right demand from customers facilitates implementation	Need for resource allocation for implementation	-	-	Sub-supplier support and alternate raw material availability	Personal quest among employees on sustainability topics	-	-	Need for understanding the environmental impact of the firm's activities	Legislative compliance is a major driver in DfS implementation	-
Pignoso et al. (2013)	Literature review, interviews and action research	-	An environmental policy across the organisation is prerequisite for eco-design activities	Need for strong connection between management and PDP in eco-design	-	Imbibing life cycle perspective among employees is needed	Clearly define goals to set and indicators to gauge improvement	-	Integrate sustainability in the daily activities of the firm	Lack of information is the right tool is an issue	Formulating and following legal requirements is in indication of a maturity level	Ensure commitment and support to perform activities

Table 2.1 Continued

Article	Source of Data	Management Practices in DFS					Operationalising DFS					Alignment of needs and expectations
		Market Conditions	Strategic Focus	Senior Management	Communication	Collaboration with stakeholders	Organisational Culture	Targets and KPIs	Sustainability Institutionalisation	DFS Tool usage	Knowledge and skill requirement	
Deutz et al. (2013)	Interviews and Survey	Companies more involved in PR are more likely to integrate environment in design	Any step towards focussed design should accompany a business case	-	-	-	-	Functional requirements in deployment of DFS adhere to its efficiency in PD	-	Access to knowledge on environmental issues influence the concern and relevance of fit	Company size has a likely influence on the requirements to comply with legislation	-
Hallstedt et al. (2013)	Interviews and Literature Review	-	Shared mission and vision is a significant reason in supporting DFS implementation	Senior Management commitment needed to mitigate complexity	Strength in implementation practices in the ability to coordinate and cooperate within projects	Role of sustainability specialists can influence DFS implementation	Need for systematic way of incorporating knowledge for future projects	Tools should be longlisted to flag beyond technical needs	Know-how of functional aspects in choosing the right tools	-	Align sustainability in the design process early on to garner support and clarity	-
Verhulst and Boks (2012)	Case Study	-	Establishment of shared vision and sustainability topics facilitates communication on the topic	-	Spreading of information on the topic is important to inform the employees	Perception on sustainability and accompanying extra workload is an obstacle to integration	-	Right tools help develop for the improvements	DFS issues need new knowledge and acquisition on an ongoing basis	Legislation compliance is already a hard task and will add to complexity on DFS issues	Ensuring employment and involvement is crucial for engaging actors in PD	-
Santolaria et al. (2011)	Survey	Companies focus on different aspects of sustainability based on their value offering. I.e. product, process or service	-	Lack of management commitment was perceived as a major barrier to sustainability integration	Need for promotion of sustainability among designers and thereby foster collaboration with companies	-	-	Availability of affordable and accessible tools can positively influence DFS implementation	Underlines the importance of imparting regular training on sustainability issues to companies	Avoiding legislative sanctions as a driving force is proportionate to the size of the company	Perceived lack of immediate benefits from DFS projects affects motivation to engage	-
Dangelico and Pignat (2010)	Case Study	Environmental prioritisation for products is needed to move both customer and company	Targets and objectives are forwarded with DFS	Environmental initiatives can be tedious and will need managerial skills/commitment to be effective	-	Commitment to social norms and regulations influences a company's green initiatives	Formal methods to transfer knowledge and changing needs around DFS is needed to guide DFS development	-	-	To have compliance with regulations is a motivation to push for integrating DFS is a key challenge	Integrating and aligning environmental aspects to conventional PDP is a key challenge	-
Boks (2006)	Survey and interviews	Customer sentiments influence the success or failure of it	Sustainability issues should be included in the company's overall strategy	Ensure equal footing for sustainability issues such as quality and cost	Role of interdepartmental interactions on DFS topics within the company	Ensuring the presence of DFS issues in all activities of the company	Systematised implementation practices avoid the dependence on individual eco-champions	Challenge in identifying and familiarising oneself with relevant tools	-	-	Impact of gap between DFS proponents and executors	-

Table 2.1 Continued

Article	Source of Data	Management Practices in DFS					Operationalising DFS				Alignment of needs and expectations			
		Market Conditions	Strategic Focus	Senior Management	Communication	Collaboration with stakeholders	Organisational Culture	Targets and KPIs	Sustainability Institutionalisation	DIS Tool usage		Knowledge and skill requirement	Compliance	
Johansson et al. (2007)	Case Study	Environmental analysis backed by business case of DFS products helps integrating environmental focus into the businesses	-	-	-	-	-	-	-	-	-	-	-	Unclear organisational structure can contribute to confusion on responsibilities
Johansson and Magnusson (2006)	Case Study	-	-	Role of leadership is vital in clarifying expectations from each stakeholder	Common intermediaries are required to create effective communication on green topics	Environmental projects are clearly cross-disciplinary, creating multiple competencies	Including green projects help in creating awareness and involvement	Cultural differences between general organisational units leading to different interpretations on sustainability integration	Formal integration of environmental project groups facilitate interaction with other units	Tools applied in design and backlogs get as source of communication & discussion between stakeholders	Differences in knowledge and understanding & terminologies	-	Unclear expectations and delineation of responsibilities may not be fulfilled projects	
Doppelt (2003)	Case Study	Lack of clear vision on the potential of sustainability is often counter-effective and backward driven	A rigid managerial approach leads to a lack of guidelines given to employees and less room for innovation	Progress of sustainability initiatives will be hindered without consistent exchange of clear information about its purpose	Suppliers often unable to understand the intricacies of sustainability completely, thus needing cooperation	No single unit/dept. will be able to understand the intricacies of sustainability completely, thus needing cooperation	Level of formalisation in projects can ensure early participation and transfer of knowledge from relevant actors	Success lies in institutionalising sustainability in the form of operating procedures and policies in everyday activities	Need to encourage, identify and learn mechanisms for continuous improvement among employees	Internal structures and systems should be aligned to initiate and sustain participation in company	Actual purpose of sustainability initiatives should be decoupled from mere compliance needs	-		
Johansson (2002)	Literature Review	Environmental considerations should be addressed as a business to garner greater support	Need to establish overarching goals on sustainability at both organisation and project level	Management support is vital in addressing challenges and ensuring resources needed for DFS projects	Suppliers often lack competencies crucial for DFS projects, thus necessitating collaboration with partners	Establishing a mind-set favourable of sustainability topics fosters positive environment	Sustainability issues should be included earlier on in PPP in order to be a factor for accompanying competencies	Suitable eco-design tools were identified as one of the success factors	Training and education for specific people on sustainability issues are crucial to engage stakeholders	-	-	-		
Baumann et al. (2002)	Literature Review	There is strong business case of green products	A disconnect between top-down and bottom-up approaches in implementation is counter effective	Promote and develop Environmental information systems to enable communication	Dealing with PD as standalone system is ineffective and should be seen in connection to its external and internal aspects	Lack of a systemic perspective and interaction with other actors affect uptake of eco-design	Evaluation of existing and new tools improve its usage is lacking	Information transfer from environmental experts to product developers is challenging due to different backgrounds	Environmental improvement is often driven by strict regulations	-	-	-		

Table 2.1 Continued

2.2.3 The need for tailored solutions

An analysis of the literature review results elaborated in Section 2.2 shows a certain trend in the existing research studies on DfS implementation in companies. Some of the contextual factors have found more prominence in studies than others. A numerical overview of the occurrence of different contextual factors from the reviewed literature is provided in Table 2.2. The need for focus on the new knowledge and training required while implementing sustainability in PD was the most commonly discussed topic followed by the importance of collaboration in DfS projects. Definition of target and KPIs as an influential factor in the company context was the least discussed in the 25 papers reviewed. As seen from Figure 2.4, there is a sustained research interest on the topic of company context during DfS implementation. The figure also provides an overview of the interest on different topics over the years. Organisational culture, for example, was a prominent topic of discussion in 2013.

Table 2.2: Analysis of contextual factors identified from DfS implementation literature

Contextual Factor	Occurrence in Literature
Knowledge and skill requirement	23
Collaboration with stakeholders	21
Alignment of needs and expectations	20
Strategic Focus	20
Sustainability Institutionalisation	19
DfS Tools	18
Market Conditions	16
Organisational Culture	16
Senior Management	16
Compliance	13
Communication	11
Targets and KPIs	8

Additionally, the academic discourse on “soft-side” of DfS implementation in companies can be safely assumed to be divided into the managerial practices on DfS and operationalising the managerial decisions into products and services based on the set DfS goals. Academic literature on the topic of DfS implementation has also tended to take either a descriptive or prescriptive approach while attempting to improve the uptake of DfS projects in companies. Descriptive studies have focussed on understanding the company case, the challenges they face and drivers that facilitate the implementation process in the companies (Boks, 2006; Boks and McAloone, 2009; Ceschin and Gaziulusoy, 2016; Dekoninck et al., 2016; Johansson, 2002) . Prescriptive approach on the other hand has primarily focussed in contributing to support the actual eco-design phase by prescribing tools, methods and frameworks that can help integrate sustainability concerns into PDP (Hallstedt et al., 2013; Pigosso et al., 2013).

Based on this understanding and the findings listed in Tables 2.1 and 2.2, this thesis identifies four major research domains spread along two axes. The articles reviewed were found to be falling within these domains and in certain cases overlapping some domains simultaneously. Though these domains are evidently mutually non-exclusive and exist in tandem with each other in practice, for the convenience of delimiting the research

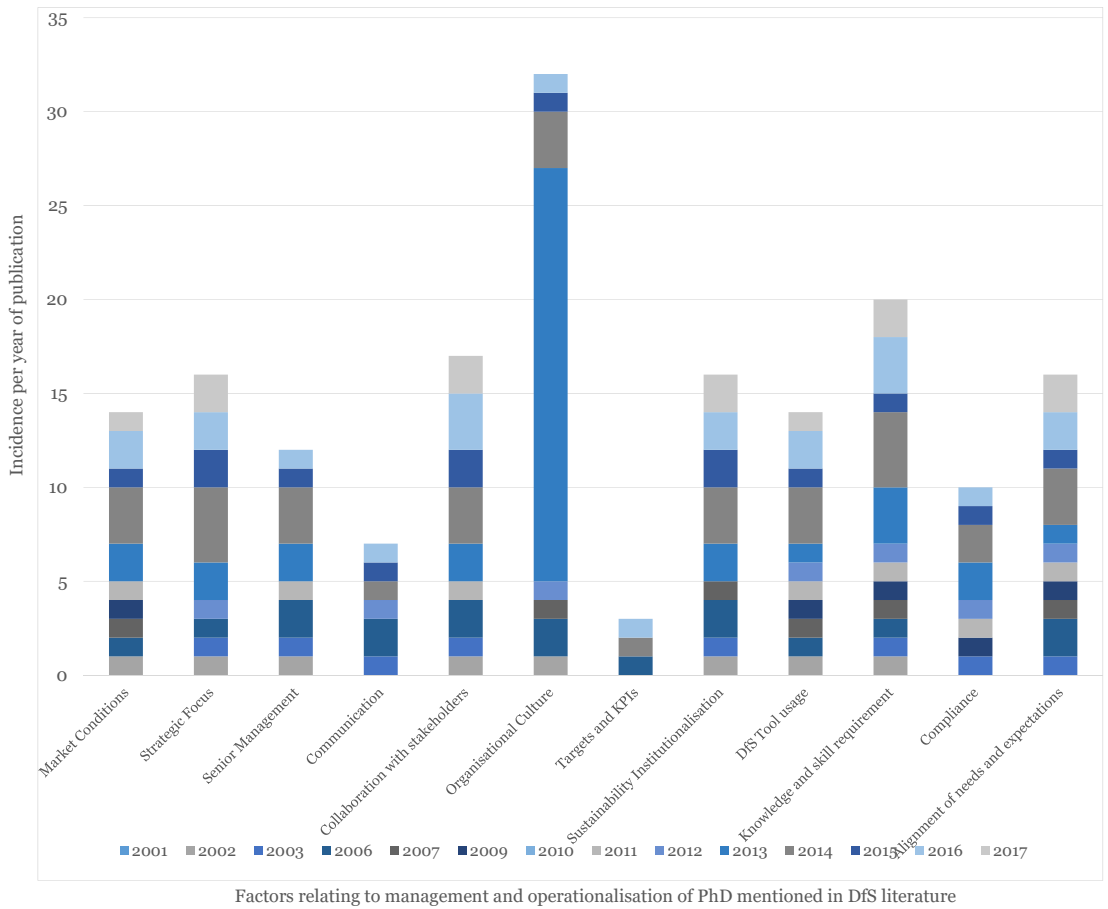


Figure 2.4: Trend of contextual factors in reviewed literature

and data collection they are illustrated as in Figure 2.5. The horizontal axis aligns the research along the two major contextual categories identified from the literature review, i.e, managerial and operational. While the vertical axis places the research contributions from academic discourse along the prescriptive and descriptive directions. Hence, in order to place this thesis within the defined frame of company context, these research domains are used as guidelines in developing the research perspectives presented in Chapter 4.

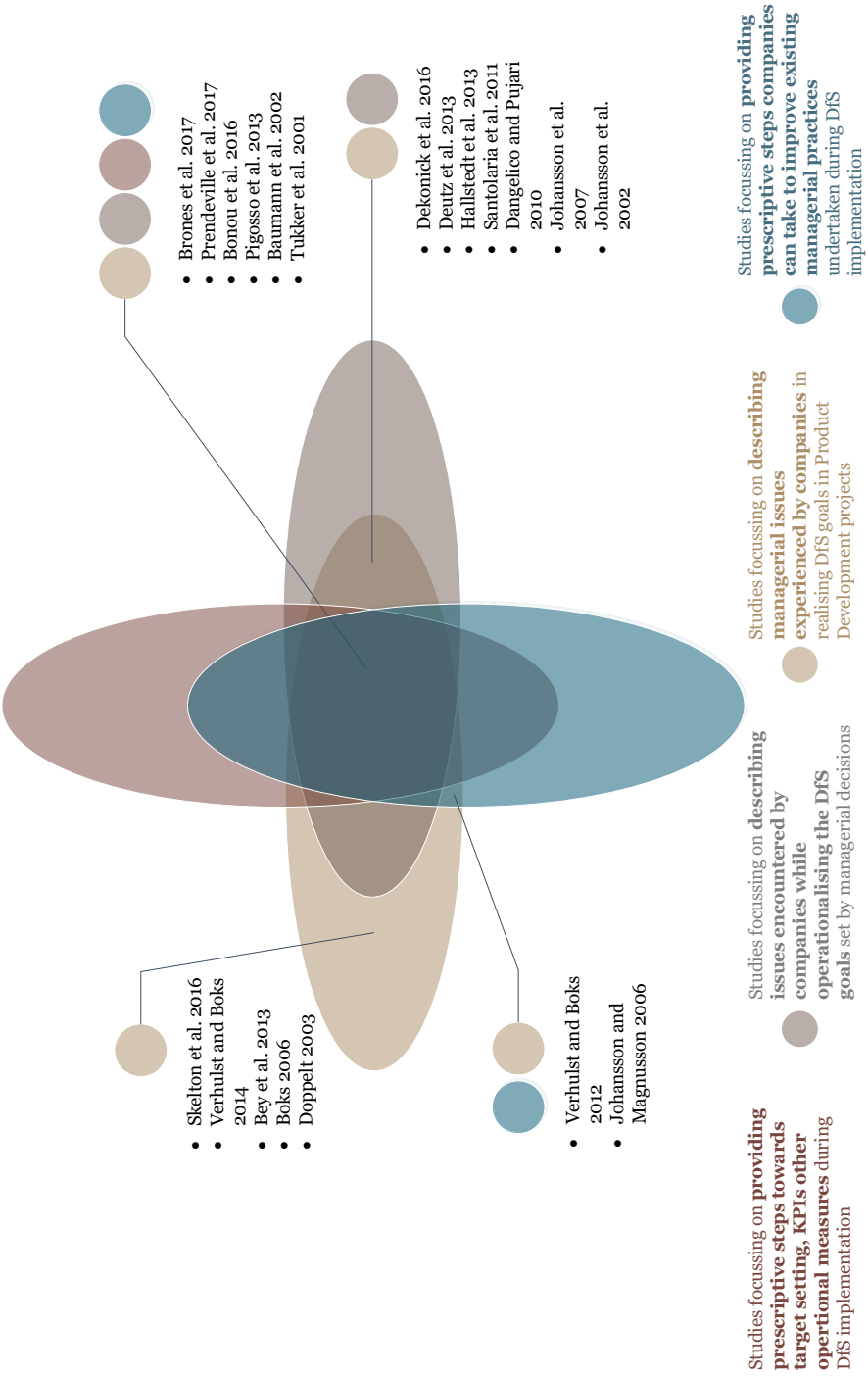


Figure 2.5: Graphical overview of the literature reviewed in Table 2.1 mapped on to managerial and operational perspectives. The contributions from these papers are further categorised into descriptive and prescriptive solutions.

2.2.4 Narrowing down on the research perspectives

As can be observed from Figures 2.4 and 2.5, researchers highlight a considerable focus on addressing the organisational knowledge and skills needed surrounding DfS implementation (in addition to technical aspects of product), better collaboration practices, and additional knowledge required from sustainability fields and also other relevant research fields during project implementation. These contributions have been predominantly descriptive in nature and very few of the articles reviewed prescribed concrete measures to overcome these challenges. As identified in the limitation part of these papers, it is often challenging to generalise the findings from qualitative studies mainly due to the relatively small sample size that can be covered within a time frame. On the other hand, qualitative research is best suited for this kind of studies as further elaborated in Chapter 3. A possible way out from this dilemma is to learn from adjacent fields of study that can positively contribute to DfS implementation. Researchers have used this approach to varying extent (Brones and Monteiro De Carvalho, 2015; Verhulst and Boks, 2012). This PhD thesis also takes a similar approach, as this serves the dual benefits of learning from more established fields within a limited time frame and also enriching it based on in-depth qualitative data from companies. It should be noted that as opposed to “studies”, this thesis uses the term “perspectives” to denote the research results. This is because, as explained above, the thesis aims at expanding the research domain around the topic of DfS and “perspectives” is a better choice as it means “the capacity to view things in their true relations or relative importance” to one other, in this case adjacent fields of study and DfS. Whereas a “study” denotes the “a careful examination or analysis of a phenomenon, development, or question” which is not the intention behind the five sub chapters in Chapter 4.

Further, to narrow down on to the exact fields of research that would be interesting to explore, this PhD thesis relied on insights from the literature summarised in Table 2.1 and Figure 2.5. One can clearly observe a push for more managerial focus in eco-design implementation over the hitherto focus on tools and methods (Dekoninck et al., 2016). Further, companies are increasingly taking up a project based approach in product development processes that researchers have found to be effective in introducing green projects throughout the organisation (Johansson and Magnusson, 2006). Based on these observations, the first study choice was to understand how conventional project management literature can contribute to DfS (Perspective 1).

Additionally, the company context and cultural aspects of a company have been established domains while discussing the relevance of non-technical aspects in DfS implementation (Boks, 2006; Domingo et al., 2015). Moreover, given the general perception of Scandinavian companies as better performers on sustainability topics, it is interesting to understand the influence of cultural context on sustainability implementation in companies (Perspective 2). Perspective 3 is designed based on the understanding that implementing sustainability aspects in companies brings in different actors that are otherwise not considered in a traditional product development process (Rio et al., 2013). Thus necessitating better collaboration and integration of activities as in New Product Development (NPD) (Kahn, 1996).

These observations from Perspective 1-3 are further explored in 4 and 5 where potential steps that can be take to address factors from Perspectives 1-3 are proposed. Insights from design literature on user personas and empirical data is used in Perspective 4 on

how to propose a method to better explain the company context. Perspective 5 focuses on translating insights from general management literature and four lenses model by Bolman and Deal (2017) to the context of DfS implementation and proposing concrete steps sustainability managers and eco-design proponents can take to realise the integration of it in a company's activities.

All in all, the literature review presented in this Chapter calls for opening up the research domains on DfS implementation from a multidimensional perspective. As an answer to this call, this thesis explores the topic of contextual factors and its influence on DfS implementation along the aforementioned five perspectives. A summary of which is provided below:

- Perspective 1:** Insights from **Project Management** literature to address the challenges stemming from multi-stakeholder and multidimensional needs associated with DfS implementation.
- Perspective 2:** Exploring the role of **cultural** setting in realising sustainability goals, with Nordic countries as a reference.
- Perspective 3:** Factors influencing the **collaboration** practices happening in a DfS implementation setting based on empirical data and how it can be improved based on insights from collaboration practices suggested in NPDs.
- Perspective 4:** Improving the customised approaches to companies' DfS challenges by defining companies as users with **personas** as in design literature.
- Perspective 5:** Drawing inspiration from general management literature and the **four lenses** framework prescribed by Bolman and Deal to provide a prescriptive approach to integrating sustainability in managerial practices.

These five perspectives are studied and discussed in detail in Chapter 4.

RESEARCH APPROACH

3.1 Project Characteristics

This PhD project has been carried out as part of the Cotutelle Agreement entered into between Norwegian University of Science and Technology (NTNU) and Technical University of Denmark (DTU). As part of this agreement, I have held multiple residencies at Kgs. Lyngby, Denmark and established a close collaboration with the research group at Division for Quantitative Sustainability Assessment (QSA) under DTU Management Engineering. Hence, certain parts of this thesis are an outcome of this joint collaboration with Raphaëlle Stewart who has been my PhD counterpart at DTU during this PhD project.

Both Stewart and I have been working on two parallel tracks on sustainability implementation in companies. Our PhD research has strived for synergy and partial complementarity in terms of the topics and to mutually contribute to each other's findings on approaches to improve sustainability implementation in companies. Stewart has in her thesis primarily focused on two topics: firstly, the uptake and integration of environmental factors in companies based on Corporate Sustainability reporting and secondly, translating the general management framework of four lenses to eco-design integration in companies. In practice, we jointly conducted the company interviews for our theses, but the interviews were designed distinctly to elicit information on the topics we were studying. This is further explained in Perspectives 3, 4 and 5 for which the interview data was used; in practice it meant that we individually made a list with proposed interview questions, which were then merged to a single interview protocol. We used separate coding protocols (and strategies) to analyse the data, as required by our own research questions, and were only involved in quality checking each other's data analysis, not in performing it. This represents also what has been the main value in our cooperation: discussing each other's approaches and analyses was very valuable, but should not be mistaken for having done the project together.

The following subsections elaborate more on the research design and methodologies adopted

in the course of this PhD.

3.2 Research Design

As warranted by extant literature on the challenges in DfS implementation and established in Chapter 2, this PhD thesis takes a multidimensional approach to answer the research questions enlisted in Section 1.2. This necessitates the researcher to build upon multiple fields and draw data from different sources, thus the researcher in such a situation takes a role that of a *bricoleur*, who builds his research from a diverse set of information to be presented as a *bricolage* (Kincheloe et al., 2018). The term *bricolage* originates from the French expression which denotes crafts-people who creatively use “left over” material from other projects to create meaningful artefacts (Rogers, 2012). As an interdisciplinary approach, bricolage avoids both the superficiality inherent in a broad methodological approach and parochialism of uni-disciplinary approaches (Kincheloe, 2001). Traditionally qualitative researchers have predominantly based their approach upon a positivist rationale, while the later generations have moved to more interpretive, post-positivist, post-colonial, post-modern and constructivist approaches (Denzin and Lincoln, 2017; Rogers, 2012). This shift according to Denzin and Lincoln (2017) has caused researchers to move towards more multidimensional approaches in qualitative research, thus relying on multiple methodologies and disciplines to build their arguments in a substantial manner (Rogers, 2012).

Weinstein and Weinstein (1991) opine that the results of a bricoleur method would be an “emergent construction” that re-configures the existing research domain through adding new methodologies, tools and interpretations to the occurrences in a changing research environment. While being challenging at one end by testing the capacity of the different methodologies the researcher adopts, such an approach also equips the researcher to move successfully beyond the boundaries of more formally documented and disseminated research practices (Yardley, 2008). There are five different types of bricoleurs that Denzin and Lincoln (2017) identify, namely, interpretive, methodological, narrative, political and theoretical bricoleurs who take an approach encompassing such a vigour and complexity. I relate myself to the methodological bricoleur, who combines a series of research tools to accomplish a meaning-making task (Rogers, 2012). As a methodological bricoleur the researcher lets the contextual contingencies existing in the researcher’s environment to decide upon which methodological tools to rely upon and in what way those tools should be used. In the case of this thesis, research methodologies for the five perspectives elaborated in Chapter 4 were designed as necessitated by the respective research perspective. Thereby, such researchers are bound to change the methodologies they use based on the emergent situation and the research topic, thus for example, could start with action-research and then move on to discourse analysis later on (Rogers, 2012; Weinstein and Weinstein, 1991).

The overall research objective of this thesis also warranted me to draw insights from multiple data sources and disciplines that can be placed adjacent to DfS implementation. A closer look at the research questions designed to answer the research objective reveals the multidisciplinary nature of the subject. This becomes even more relevant as sustainability issues in general extend beyond the conventional boundaries of product development practices in company as it requires to take in inputs from different stakeholders such as

environmental specialists, external partners, Non-Governmental Organisations (NGO), legal entities and local societies impacted by the product in different stages of its life cycle. Building on this understanding, I have constructed this PhD thesis by blocks inspired from academic disciplines which have been to a large extent kept out of academic discourse surrounding DfS implementation. These different blocks that constitute this thesis and how it contributes to the research questions are explained in the following Chapters of this thesis.

3.2.1 Research Methodology

As explained in the preceding sections, this thesis is a culmination of results emanating from five different studies that made use of a number of qualitative research methodologies to collect, structure, interpret and analyse the data. Thus, a case study approach forms the overall framing of this thesis, in which, perspectives from five different disciplines were taken and applied to the overall topic of understanding company context in DfS implementation. Case studies are a judicious choice among research methodologies when the researcher yearns to understand the actual happening in a real world setting where the researcher has little influence or control (Yin, 2009). These studies can be exploratory, explanatory or interpretive in nature and takes a theory driven deductive approach in answering the research questions. According to Yin (2013) a case study researcher uses multiple sources of information from written documents, surveys, questionnaires and other relevant information to build the case. DfS implementation being an actual case scenario in manufacturing companies that are often operating in a dynamic environment subject to influences from externalities and internal happenings, case study was an apt choice for this PhD thesis.

Further, Eisenhardt (1989) observes that case studies can serve multiple aims such as to provide description, test theory or generate theory. I have focussed on the earlier part of providing description of the company context that influence the DfS implementation scenario in companies. Eisenhardt (ibid.) also cites the use of archives, interviews, questionnaires and observations as typical sources of data collection in the case study process. Literature review has been predominantly used as the starting point in all the five research perspectives. Perspectives one and two are exclusively based on empirical data collected from relevant research studies.

Perspectives three, four and five make use of interviews to analyse, validate and translate the constructs on collaboration, user persona and general management literature to DfS context respectively. In addition to classical semi-structured interviews, the study on “company personas” (Perspective three) also made use of an interaction mapper (see Figure A.2) that is further detailed in Section 4.4. These inputs were then triangulated (Flick, 2018) with inputs from the reviewed literature and official company communiques.

All the five studies presented in Chapter 4 follow a common study design. Table 3.1 presents an overview of how this was applied in all the perspectives.

	Perspective 1 (Section 4.1)	Perspective 2 (Section 4.2)	Perspective 3 (Section 4.3)	Perspective 4 (Section 4.4)	Perspective 5 (Section 4.5)
Research Methodology	Literature Review (Section 4.1.1)	Literature Review (Section 4.2.1)	Literature Review and Interviews (Section 4.3.1)	Literature Review and Interviews (Section 4.4.1)	Literature Review and Interviews (Section 4.5.1)
Theoretical Background	Project Management Literature (Section 4.1.2)	Nordic organisational culture (Section 4.2.2)	Collaboration in NPD (Section 4.3.2)	User personas from design studies (Section 4.4.2)	Four lenses management framework (Section 4.5.2)
Contributions to overall discussion	Learning from PM practices in DfS context (Section 4.1.3, 4.1.4)	Socio-cultural factors of Scandinavian organisations (Section 4.2.3, 4.2.4)	Factors influencing collaboration practices (Section 4.3.3, 4.3.4)	14 Persona dimensions (Section 4.4.3, 4.4.4)	Managerial measures to integrate DfS (Section 4.5.3, 4.5.4)

Table 3.1: Overview of the research design adopted in the five different research perspectives presented in Chapter 4. Sections corresponding to each research step is mentioned in parentheses. PM = Project Management, NPD = New Product Development, DfS = Design for Sustainability.

RESULTS

This chapter presents the five different perspectives explored as part of this PhD thesis to answer the research questions enlisted in Section 1.2. As illustrated in Table 3.1 the first subsection of this chapter presents the learning from Project Management literature that can potentially improve DfS implementation in companies. Perspective two presented in Section 4.2 investigates the socio-cultural factors of the Nordic region that influence the sustainability activities of organisations. The section also builds on literature from Nordic culture to study its potential influence on DfS implementation in companies. Sections 4.3, 4.4 and 4.5 are based on insights from interviews held in seven Norwegian and Danish case companies. Section 4.3 presents the results on the influence of different collaboration activities happening internally and externally in a company involved in DfS implementation. Section 4.4 explores the potential of using user personas from design literature to develop a company persona description that can help researchers and sustainability consultants understand the company context better. The final perspective in Section 4.5 translates findings from general management literature to DfS implementation context to prescribe steps management can take to improve the the implementation process based on four different lenses as proposed by Bolmann and Deal (2017), namely, architect, catalyst, prophet and advocate.

4.1 Perspective 1: Learning from Project Management literature

The content presented in this Section is adapted from Ali et al. (2016a) published as part of this thesis.

As established in Section 2.2, the reviewed literature on the relevance of company context in DfS implementation shows that it would be interesting to look into adjacent fields of study such as project management to inspire and improve DfS implementation in an increasingly project based environment. More recently, Brones et al., 2014 observe that

the shift towards more management focus in DfS implementation, increasing relevance of internal stimuli on DfS topics, new competencies surrounding sustainability topics, among others, have necessitated research to explore the need for an overview of the various activities associated with DfS in the industry. Further, the need to have a holistic approach by considering various elements of Design of Sustainability as part of a single system has also been argued for in the environment friendly design context (Brones and Monteiro De Carvalho, 2015; Fet et al., 2013). The need to factor for increasing organisational complexities and importance of communication at different stages of eco-design product development (Boks, 2006; Verhulst and Boks, 2012) also highlight the need for a project based approach to the topic of DfS.

Elsewhere, researchers have also observed that project management forms the “core business methodology” of most companies and therefore cannot be excluded from the discussion on sustainability. It is in this context that this section explores the applicability and presence of project management focus in the existing DfS literature. For the purpose of research and analysis, this perspective uses the following definition of project management from the Project Management Body of Knowledge (4th Edition):

Project management is the application of knowledge, skill, tools and techniques to project activities to meet the project requirement.

4.1.1 Research Methodology

As the topics of DfS and Project Management (PM) are quite diverse, the study explores both topics in a two stage literature review method, as illustrated in Figure 4.1. The two stage analysis was opted for as it helped in providing a streamlined overview of the state-of-the art of both PM and DfS in relation to each other. The first stage aimed at establishing this overview of PM and DfS. The second stage analysed these findings to explore the need and possibilities that arise when PM is studied and researched in DfS milieu.

For streamlining the literature review process, two major databases were selected, namely, ISI Web of Science and Scopus. These selections were made mainly due to the detailed meta-data available from these databases that facilitated supplementary research and the relevance of DfS literature in these databases. The literature review process looked in to journal and conference publications that discussed topics regarding DfS, Project Management, managerial issues affecting DfS implementation, managerial initiatives such as change management used to realise sustainability goals in PDP, eco-design tools and methods applied in the process etc.

4.1.2 Theoretical Findings

DfS and Project management - learning points

The literature review revealed that both DfS and PM have been studied in depth by the academia in its own domains, while the overlap between these two topics were seldom found in research papers. A total of 52 articles were identified on ISI Web of Science while the list stood at 67 in the Scopus database. This list was further shortened to

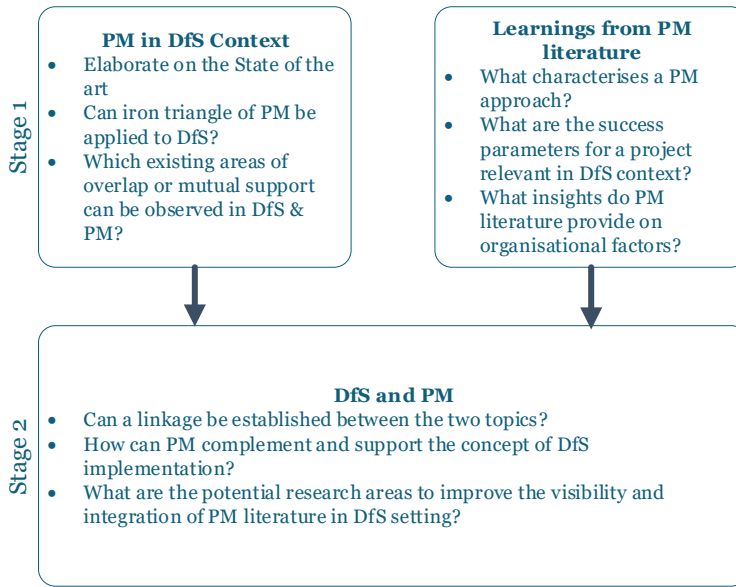


Figure 4.1: The two stage research methodology adopted for the study. PM = Project Management, DfS = DfS

32 by eliminating articles recurring in both the databases and scoping down to articles discussing managerial topics in DfS/eco-design implementation context.

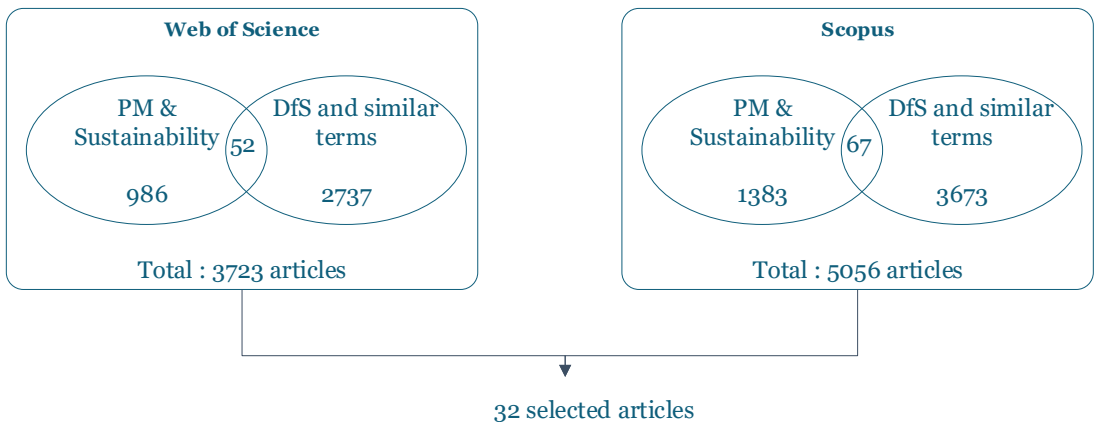


Figure 4.2: Literature search results from Scopus and ISI Web of Science

The first part of Stage 1 analysis looked into the PM literature to identify and highlight features from project management processes, organisational parameters and success factors that can augment and refine the DfS context. Project Management literature is vast and deals with a multitude of issues concerning projects in varying company environments. Therefore, in order to streamline the course of discussion presented in this perspective, this PhD thesis focussed on three segments which I believe are relevant for

the context of this thesis.

Project management literature commonly identifies three basic success factors for any project, namely, cost, time and quality (Atkinson, 1999; Project Management Institute, 2008). Known as the iron triangle, these factors evaluate how successful the project has been in achieving the stated quality within the budgeted cost and estimated time. But to arrive at this evaluation stage, a project passes through different processes. The Project Management Body of Knowledge (PMBoK) identifies five different processes that need to be carried out simultaneously for swift information flow between various stakeholders of the project and to meet the overall project requirements (Project Management Institute, 2008). These are namely, initiating, planning, executing, monitoring and controlling, and finally closing process group. Activities under each of these process groups are illustrated in Figure 4.3.

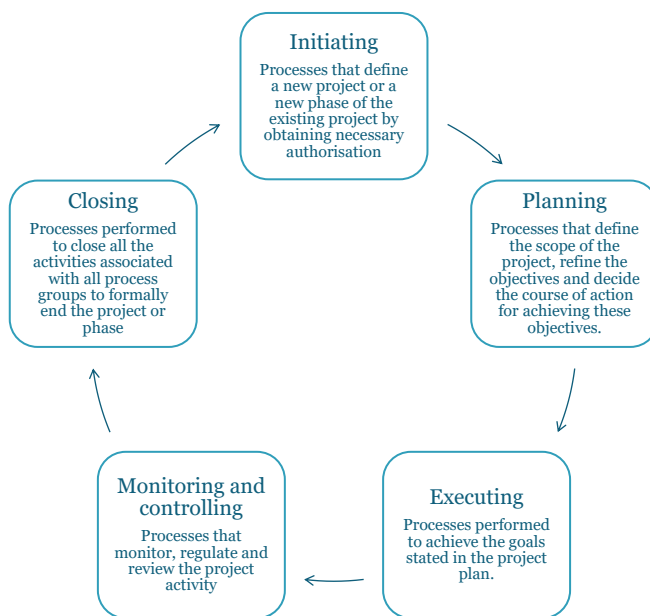


Figure 4.3: The five Project Management process groups - an illustration (Project Management Institute, 2008)

These five processes indeed streamline the transition from conception of the product/project to the final delivery and feedback loop involved in it. These processes do not occur in isolation and thus interact with each other in continuity. Especially, the “monitoring and controlling process” process group stresses upon the need for knowledge transfer between the organisational stakeholders and different departments in order to facilitate similar projects in the future.

Further, learning from completed projects is a vital element in project implementation process, even in the DfS context. Boks and Stevels (2003) mention this as one of the main reasons why an environmental benchmarking tool was developed by Philips, as most environmental design issues were otherwise often addressed in isolation from the day to day to business. In order to materialise this learning process from completed projects,

Schindler and Eppler (2003) identify a series of success factors that can be garnered during the debriefing phase of projects. The list includes continuous and regular capture of important project experiences, presence of an external/neutral moderator for the final debriefing session, a collective and interactive evaluation and analysis of experiences from individual members, among others.

In tandem with this capture of knowledge gained, companies should also be able to successfully transfer this knowledge to ongoing and upcoming projects. This often requires a good overview of the cultural and managerial aspects of the receiver. In case of DfS implementation, this will pertain to new product development projects that imbibe sustainability aspects in PDP. As mentioned in Chapter 2, literature on DfS studies highlight the importance of such managerial aspects in the DfS/Eco-design context. Some of these factors identified and mentioned earlier in this thesis include social and psychological aspects of individuals, lack of commitment and unwillingness to cooperate among other organizational complexities (Baumann et al., 2002; Boks, 2006; Johansson, 2002). The literature review on PM carried as part of this research perspective also identified certain discussions on the role of organizational parameters in successfully realising project goals.

In its definition of PM, Project Management Institute (PMI) identifies human resource management as one of the six fundamental functions of project management (Project Management Institute, 2008), the other five being the project goal, project description, project deadline, project location and project approach. Belout and Gauvreau (2004) observe that project personnel have a considerable effect on the success of the projects and hence need to be taken into consideration while deciding upon the staffing process in projects. The PMBoK draws out a 4 stage process for human resource management in projects. These processes range from defining the project scope for each individual involved, the competence required to develop and manage the project team.

A crucial factor in successfully controlling the soft side of project teams is to educate and create a consensus among the people involved on the expected outcomes of the project and the ways to achieve it. A few of the tools and techniques identified for this purpose are as follows (Project Management Institute, 2008):

- Organisation chart and position description
- Networking and team building activities
- Co-location of employees involved
- Recognition and awards for performances
- Continuous and regular conflict management
- Project performance appraisals
- Observation and conversation
- Issue logs

Thus, the project management literature has a great potential in contributing to the expanding field of DfS from both theoretical and practical perspectives. These insights on the systematic approaches in PM literature and their possible contributions to DfS are discussed in the following sections.

The second part of Stage 1 analysis reviewed how scientific research on PM has been featured in a DfS context. Though articles exclusively on this are very few, a general observation in these shortlisted articles is that emphasis on the triple success factor of project management, i.e time, cost and quality is rarely addressed from a DfS perspective. So is the case with execution phase of eco-design projects. As observed from similar case studies by Brones et al. (2014) and Wu and Pheng Low (2010), research on DfS topics have predominantly focussed on the technical issues of the product being developed, tools, methods and frameworks to aid designers in selecting materials, analysing the environmental impact of the product and so on. Thus as stated earlier in this thesis, the focus on managing the process itself has been relatively low.

Nevertheless, Santolaria et al. (2011) observe that in reality, DfS calls for continuous improvement and innovation rather than incremental changes to products to remain valid and to deliver the desired results. The product innovation process, as discussed in the literature, rather reflects a chaotic circular model instead of the conventional linear model of product development (Buijs, 2003). This chaotic continuous improvement cycle warrants a structured and systematic approach to managing product development projects, thus increasing the significance of project management practices in DfS implementation processes.

Further, case studies on integrating DfS into PDP in various industrial settings demonstrate that the concept of integrated thinking between various stakeholders and parameters lead to real transformation of design practices (Knight and Jenkins, 2009; Reed and Gordon, 2000; Tingstrm and Karlsson, 2006). Based on a case study carried out at ABB, a large Swedish company in energy and automation, Tingstrm et al., 2006 demonstrate how the integration of the sustainability thinking in project management practices enabled the case company in successfully improving the environmental performance of their products. As identified in Chapter 2 a general trend in DfS literature has been the development of numerous tools, methods and frameworks aimed at facilitating the application of both technical and managerial practices associated with DfS. Pigozzo et al. (2013) identified 126 such tools developed by researchers and consultants. However, the low level of usage of these tools (Baumann et al., 2002; Hallstedt et al., 2013) provide a rationale for investigating to what extent elements of project management have been embedded in these tools, as a precursor for understanding how project management elements can be integrated with some degree of feasibility.

A good number of reviews and analyses on eco-design tools presented by the academia (Birch et al., 2012; Bovea and Prez-Belis, 2012; Byggeth and Hochschorner, 2006; Knight and Jenkins, 2009; Navarro et al., 2005) studied the usability, functionality and depth of results these tools present. A general observation from these reviews is that project management elements or processes are either entirely missing or lack focus in these tools. This may primarily be the case because the targeted users of these tools have been mostly designers, without focus on others involved in the product development process and the management thereof. Most of these tools were made for standalone purposes and thus are void of elements intended to include these tools in the daily business processes. Some exceptions are eco-design tools such as PILOT by Wimmer et al. (2008), Environmental benchmarking an internal tool by Philips, EIME (Environmental Information and Management Explorer) provided by CODDE are some of the eco-design tools that were meant to be integrated in daily businesses. The environmental benchmarking, for example, was developed in order to overcome the shortcomings in resolving environmental issues related

to design as isolated projects. The main weakness being the lack of follow up of executed projects and transfer of knowledge acquired from it (Boks and Stevels, 2003). Though some elements of project management literature can be found in these eco-design tools, they lack the depth on project execution processes and focus on organizational factors explained earlier in this stage. A few other widely discussed tools such as the MET Matrix, Ten Golden rules and LiDS wheels are mostly checklists or guidelines aimed at highlighting the important factors that designers need to consider when addressing eco-design issues (Byggeth and Hochschorner, 2006; Luttrupp and Lagerstedt, 2006) thus excluding the execution phase of such eco-design initiative from its scope.

DfS and Project Management interlinkage, need and possibility

The second and final stage of the analysis in this research perspective aimed at establishing the need for interlinking PM and DfS. For this purpose, possible learning points from PM literature that could be used to overcome the various DfS implementation challenges and barriers were looked for. In addition to the already enlisted challenges and gaps in DfS implementation (in Chapters 1 and 2) the following paragraph summarises some of the major challenges that can be potentially addressed based on inputs from PM literature.

Communication challenges existing between various stakeholders, proponents and units involved in DfS implementation area often identified as a barrier to effective DfS implementation. Researchers identify effective communication and closing the gap between proposed and expected sustainability solutions as one of the most important success factors (Boks, 2006; Byggeth and Hochschorner, 2006; Johansson, 2002). Further, Waage (2007) argues that another main challenge with DfS is the difficulty in material coordination and right material selection. The difficulty in this is mainly twofold, firstly due to the inadequate, inappropriate or unverified information on the environmental performance of many materials (Aschehoug et al., 2012; Byggeth and Hochschorner, 2006; Mayyas et al., 2012). This in turn complicates the decision making process surrounding material selection in a sustainability focussed product. Secondly, most sustainability initiatives according to Waage (2007) are devoid of the larger picture where the impact accumulates due to large volumes of the same product. As stated in the preceding section, PM literature puts forward multiple steps to overcome these challenges in projects involving stakeholders with different background and complex information flow. Establishing proper communication protocols and ensuring clear overview over different activities in the project throughout the project group were some of the identified steps in this direction. Robichaud and S. Anantatmula (2011) observe that the “charrettes” have great potential in facilitating dialogue among the stakeholders and also in highlighting the interest of all the concerned partners right from the beginning of a DfS project. Premium cost associated with environmental friendly products has been another challenge to the field of DfS. Case studies from the automobile, metal production and construction industries show that price has been a major deciding factor in DfS integration Hwang and Tan (2012), Mayyas et al. (2012), and Steen and Borg (2002). PMBoK outlines a set of best project management practices in-order to ensure timely delivery of projects within the budgeted cost, steps include timely allocation of resources, planning and preparing for contingencies and resource crunches. It can be safely hypothesised that adopting these measures to PDP in DfS projects will help in mitigating the price challenges to some extent.

4.1.3 Overall contributions to this thesis

The results from this study show that PM has seldom been focused upon in the DfS discourse. On the contrary, the PM literature reviewed present insightful views on addressing various issues commonly faced in DfS. The PM process groups mentioned in the preceding sections is a case in point on how to approach any eco-design project in a systematic manner.

Another major point of intersection between DfS and PM is the methods and needs for addressing human or organizational related factors in eco-design projects. This further follows the overarching theme of this PhD thesis, i.e the context of the company involved in DfS implementation. The analysis presented on the barriers faced by DfS and solutions from project management literature reveals the complimentary nature of DfS and PM. This is all the more important as several researchers support the view that barriers to DfS are individual and company specific (Bertels et al., 2010; Linnenluecke et al., 2009), which is also the case with project management practices. These observations indeed present an interesting field of research for further study on intersection between PM and DfS.

A limitation in this exploratory study could be the research methodology used, mainly because the topics discussed in this paper are broad and diverse. As mentioned earlier, academic work addressing both PM and DfS together is scarce and nevertheless as hypothesised earlier in this thesis, the domain of DfS implementation has immense potential to learn from adjacent fields of research as established in this perspective. For coherence in the discussion presented, literature on PM was further restricted only a select few elements of PM as elaborated earlier in this section. This might have potentially affected the breadth of discussion presented.

To conclude, based on existing literature, Perspective 1 of this thesis carried out an exploratory study on the role and presence of project management literature in the DfS context. The study was carried out in a two stage process, in which Stage one examined potential learning points from project management literature and state of the art in DfS implementation. While Stage two analysed the possible inter-linkages that can be established between the two (DfS and PM), based on extant literature presented in Chapters 1 and 2 and insights from PM discussed in Section 4.1.2. The major scientific contribution from this perspective has been two fold. Firstly, as argued upon in the earlier sections of this article, the study reveals a clear missing linkage between PM and DfS. Secondly, focus on PM holds great potential for the field of DfS, especially from the latter's focus on organizational parameters and human side factors in realising successful projects. Thus, these highlight the possible interconnections between two topics that have been studied by the academia in singularity, to a large extent.

These findings are further revisited later in this thesis (Section 5.1) and discussed in tandem with the research questions presented in Section 1.2.

4.2 Perspective 2: Nordic Culture and DfS implementation

The content presented in this Section is adapted from Ali et al., 2016b published as part of this thesis.

As discussed earlier in this thesis, in order to understand the company context better, it is also important to look into the cultural aspects in which they operate. Subsequently, this research perspective studies the impact of the cultural aspects of the region a company is based in. Given the Nordic nature of this PhD project established between Norway and Denmark, it was interesting to explore how the cultural and organisational aspects prevailing in the Nordic region impact the sustainability activities of the company. Is there something called the ‘Nordic Approach’? If so, what characterises it and how do these characteristics facilitate or hinder sustainability activities in the region? These were the two major questions probed in this research perspective.

Further, the increased internationalisation and complex inter-dependencies between markets emphasise an even larger significance of these geographic factors in discussions on DfS. Hofstede (1983) observes that nationality is a crucial part of management for three reasons. Firstly, nations are politically rooted historical units with mutually differing formal institutions that are hard to converge. Secondly, the sociological factor of common identity among people from a nation or region distinguishes them from the rest. Thirdly, the psychological factor, that our thinking is partly influenced by our culture, family and childhood experiences, which differ from country to country. These observations make it an interesting academic proposition to explore those factors that are unique to a region or country, and that could possibly have an impact on the successful implementation of DfS strategies.

Scandinavian industries have been first movers in various sustainability initiatives and are also home to many companies that perform well in sustainability indices around the globe. This includes the Dow-Jones Sustainability Index (DJSI) and the Global 100 Index. The ‘Nordic’ countries which include Norway, Sweden, Denmark, Finland and Iceland have been widely discussed in sustainability and organisational management context in both industrial reports and academic literature (Emmelin, 1998; Lindell and Arvonen, 1996; Lindell and Karagozoglu, 2001; Smith et al., 2003). Further, the term approach for the purpose of this research is defined as ‘to make advances to, especially in order to create a desired result’ (Webster, 2006). The usage ‘Nordic approach’ in the perspective of this PhD thus entails the Nordic method of carrying out tasks and style of functioning in the organisation. Furthermore, the socio-cultural similarity existing among the Scandinavian countries makes it a good choice to be analysed as a single unit (Poulsen, 1988). Thus to break down the two major questions mentioned in the above paragraph, this research work aimed at reviewing existing evidence in literature for a ‘Nordic approach’ that distinguishes business activities within Nordic companies and industries from the rest of the world. Further, also explores how an understanding of such an approach, if it exists, can help ongoing academic research and discussions on sustainability implementation in industries. Subsequently, the ‘Nordic approach’ observed in a broader set of literature is considered as the unit of analysis for Perspective 2 of this thesis.

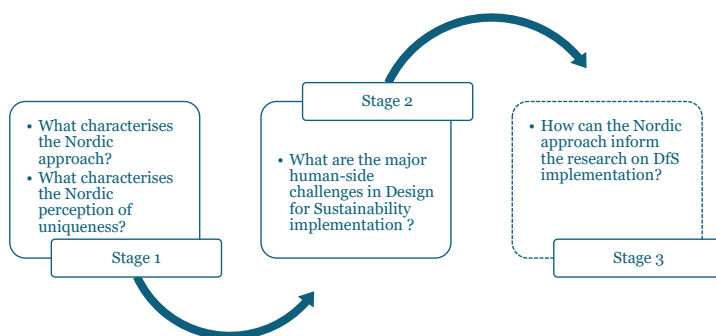


Figure 4.4: Three stage research process adopted for Perspective 2

4.2.1 Research Methodology

A comprehensive search string covering various dimensions of the topic of study was developed to streamline the literature search and to include research and findings from relevant sources. Scopus was selected as the main scientific database mainly because of two reasons, firstly, the detailed meta-data available from this database facilitated supplementary research and secondly, the depth of relevant literature in this database. The search strings used in the literature review process were related to 1) literature on the geographic area of Scandinavia, 2) academic work on institutional entities, and 3) different organisational parameters that can be observed in such institutional entities. Further, in order to identify the insights from existing academic research covering Scandinavia and the topic of sustainability, an additional list of independent variables were also used in the literature search process.

Subsequently, as illustrated in Figure 4.4, a three stage research method was devised to investigate the factors outlined in the preceding section. Stage 1 of the research work involved finding factors that characterised the Nordic style of functioning in different academic segments. Further, it also studied how the Nordic style is different from other identified academic works on regional and organisational culture (Section 4.2.2). In Stage 2, some of the commonly identified human-side challenges in DfS implementation were explored in light of the findings elaborated in Stage 1 (Section 4.2.2). Together this provides food for discussion on how insights on the Nordic style may benefit DfS implementation. This is briefly touched upon in Section 4.2.3, thus indicated by dotted lines (Stage 3).

4.2.2 Theoretical Findings

This section presents the findings on ‘Nordic approach’ and on DfS implementation that was identified in the literature review process. A total of 37 articles were identified and selected for analysis. These articles were selected based upon their focus on the Nordic organisational culture and comparative discussions on other regional cultures. Since the main focus of this article is on understanding the Nordic approach, only 9 of the selected articles discuss the DfS literature and implementation challenges.

Smith et al. (2003) observe that research on the Nordic management style has been mostly

characterised by researchers from two different backgrounds. The first kind of researchers who are from outside the Nordic geographic region approached the Nordic management style and its way of functioning as part of an attempt to highlight existing global variations in the field. Hofstede (1980) and House et al. (2004) are some examples. In contrast, researchers from within the Nordic region have put larger focus on bringing out attributes considered unique to that region (e.g.: Hvid et al. (2011) and Hall et al. (2009)). The latter academic work has thereby helped in highlighting the Nordic uniqueness in terms of culture and organisational characteristics. Both these findings are further discussed in the following section.

Stage 1: The Nordic socio-cultural dimension

In his classic survey covering employees of a multinational company with presence in 40 different countries, Hofstede (1980) states that culture is characterised by four major dimensions;

- Power distance (unequal versus equal)
- Uncertainty avoidance
- Individualism/Collectivism (alone versus together); and
- Masculinity/Femininity (tough versus tender)

Among these four, Hofstede observes that the Nordic countries along with the Netherlands have very low power distance among the employees in the organisation. The Nordic countries were also found to be more individualistic in their approach, with initiatives driven by subordinates.

Hofstede further characterises the Nordic countries as having a more feminine culture, femininity according to him relates to the similar gender roles existing among both male and female (Smith et al., 2003). This mainly stems from the gender equality (termed as *likestilling* in Norwegian) approach for which the Scandinavian countries are known for. This also follows the findings of Hofstede (1998), where the author identifies the feminine culture existing in the Nordic countries as a main reason for these countries having a larger female presence in leadership roles in the society and better work and family life balance.

However, Hofstede's dimensions address culture on a very general, national culture level and do not incorporate other societal or personal characteristics that may be typical for a certain geographic location and/or state of welfare. In a different take on this, Lewis and Cooper (1995) propose an agenda for organisational change in the work and family interface setting by highlighting the individual, organisational, family and community costs entailing an improper work and social life balance. These costs include personal work related stress, low efficiency in work, absenteeism and reduced quality of life. The Nordic countries have come out well in studies on the quality of life and work life balance. In a study comparing five different European countries in terms of work-life balance, Crompton and Lyonette (2006) observe that Norway and Finland score better than Portugal, France and the United Kingdom. Researchers opine that the long standing public policy initiatives since the 1970s in Scandinavia played a big role in achieving this balance between employee and family life (Gallie, 2003; Lewis and Cooper, 1995). These observations in

literature lead to the concrete conclusions on how Nordic traditions and long standing cultural norms have served as a determining factor in shaping organisational characteristics in the Nordics. The following subsections investigate some of these organisational characteristics in detail.

Flat organisational structure in Nordics its manifestations The Nordic countries are known for their relatively flat organisational structure, which distinguishes its style of functioning. In a cross-cultural study between the market orientation of Nordic and US based firms, Selnes et al. (1996) observe that national context of the firms play a decisive role in its response to the market changes. The studies showed that interdepartmental conflicts were found to be low in Scandinavian firms and interdepartmental connectedness was on a higher level.

Empirical studies show that shared leadership in firms improve the team performance when supported with proper team autonomy in functioning, control and discretion over tasks and conditions (Fausing et al., 2013). The flat working structure in the Nordic organisations in turn results in increased autonomy and low power distance within the management levels (Hofstede, 1980; Kasvio et al., 2012). In a cross cutting review of organisational studies on the Nordic work culture, Hasle and Srensen (2013) establish that employees in the Nordics are autonomous beings possessing individual and collective aspirations that drive their commitment and increase their individual contribution to the firm's activities.

High degree of stakeholder approach Another feature identified in the Nordic style of organisational working is the increased stakeholder involvement in the functioning of the organisations (Lindell and Arvonen, 1996). Kasvio et al. (2012) mention a Norwegian example of how high degree of stakeholder involvement benefits all concerned parties in an organisational setting. This also follows Monthoux (1991)'s view on a participatory style of working in Swedish companies, where people are taken seriously only when they speak on as part of the collective group appreciating different views in the group. Another study on national culture and hierarchy also concludes that this participatory style of organisational functioning is found to be ingrained in Nordic organisations. This leads to an improved cohesiveness among different organisational units within the firm leading to improved conflict resolution and lesser uncertainty in activities (Laurent, 1983).

Task orientation In a comparative case study on the Nordic management style in an European context, Lindell and Arvonen (1996) observe that Nordic managers stress upon the need for proper planning and order in the activities of the company and communicate the details more with their subordinates. The Nordic organisations are thus less task oriented, giving more freedom to the employees to achieve the targets based on the inputs they receive (Smith et al., 2003).

Employee orientation In the study mentioned earlier, Lindell and Arvonen (1996) also study the employee orientation in the Nordic firms, and find that Nordic managers allowed employees to make decisions and showed regard for the individuals they were.

The article observe that it was based on the mutual trust and consideration that the employee and manager had for each other.

Innovation driven Exploring the influence of management control in empowering the employees, Simons (1995) argue that effective managers empower their employees, giving them enough room to innovate and add value in their activities. The Nordic managers are known to encourage their employees to think along new lines and are open to discuss new ideas (Lindell and Arvonen, 1996; Smith et al., 2003).

Stage 2: Design for Sustainability implementation human-side challenges and needs

Given that the scope of this thesis and the discussions in preceding Chapters, the different DfS implementation challenges are not presented in detail in this Section. Readers are kindly advised to refer to Chapter 2 for the theoretical background of this thesis which discusses this in detail. However, in order to present the findings on ‘Nordic Approach’ in tandem with the DfS challenges it can potentially resolve, a short summary of it is provided in Table 4.1. More can also be read in the respective Section of the appended paper (See Paper II).

4.2.3 Overall contributions to this thesis

To summarise, based on existing academic literature, insights on what entails a ‘Nordic approach’ were explored and presented. As illustrated in Figure 4.5, the ‘Nordic approach’ is characterised by a number of features originating from the socio-cultural dimension of the region. Therefore, this thesis would like to propose that understanding and addressing these features may provide insights in understanding conditions for successful implementation of Design for Sustainability (DfS) in a Nordic context. As so far, literature on DfS implementation does not distinguish between different geographic reasons, this goes two ways:

- A better understanding can provide additional, geographic-specific insights on how DfS implementation in the Nordic business culture can be supported
- Should it become clear that the Nordic business culture is specifically supportive to DfS implementation, it provides food for thought on which elements of the Nordic approach may be implemented in other suitable geographic regions.

Further, elements of the Nordic approach may support aspects such as internal communication, creativity, stakeholder dialogue and participation. Also, the high level of individuality and relatively flat structure of organisations may facilitate communication between individuals and departments, thus overcoming challenges related to communication, cooperation, and favouring bottom-up initiatives and creativity. Similarly, a tradition for stakeholder participation and mutual trust may contribute for more efficient innovation processes, faster decision making processes, and avoid distrust among different parties that are all needed to be on board to push sustainable innovations forward. This also follows that certain Nordic characteristics identified in this study could also potentially hinder DfS implementation in companies. Perspectives 4 and 5 presented in this thesis

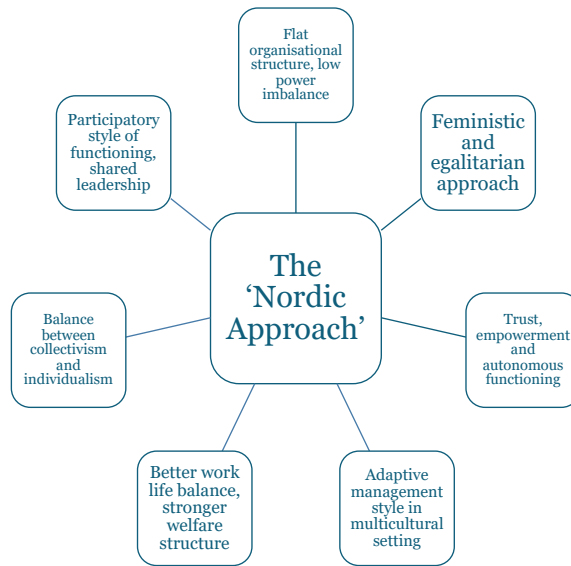


Figure 4.5: Factors characterising the 'Nordic Approach' an illustration

takes these points further and draw upon insights from case company interviews to materialise steps in order to incorporate the cultural and human side perspectives into tool, methodology and strategy development for DfS implementation. Furthermore, Table A.1 presents a graphical summary of how the Nordic factors can be conducive or hindering to DfS implementation process. The table is not included here, but rather in the Appendix since it was not part of the Paper published based on this study.

Table 4.1: ‘Nordic Approach’ and DfS - drawing parallels. Columns 1 and 2 present a summary of findings from Perspective 2. Third column identifies potential coupling points where Nordic characteristics can address DfS challenges

Identified from ‘Nordic approach’ literature	Factors identified from DfS implementation literature that are relevant in the context	Possible coupling and potential benefit area
Flat structure of organisation (Selnes et al., 1996)	Need for effective communication (Boks, 2006)	Facilitates easy and open communication
Individualistic behaviour (Hofstede, 1980)	Need for creativity and self-driven individuals (Baumann et al., 2002)	Supports (bottom-up) creativity in DfS product development process
Lesser uncertainty (Laurent, 1983)	Need for cooperation (Hemel and Cramer, 2002)	Avoids uncertainty and conflict creation during DfS implementation
Proper planning and order (Smith et al., 2003)	Need for proper dissemination of sustainability information (Aschehoug et al., 2012)	Ensures proper dissemination of information enhancing overall competitiveness of the firm.
High degree of stakeholder approach (Lindell and Arvonen, 1996)	Need for complete stakeholder involvement (Tukker et al., 2001)	Improved decision making process, avoiding inward focus
Strong employee orientation (Lindell and Arvonen, 1996)	Need for empowerment (Verhulst and Boks, 2014)	Easier translation of goals to action, increase acceptance
Innovation driven (Smith et al., 2003)	Need for continuous improvement in eco-design environment (Santolaria et al., 2011)	Exploiting creative approaches in DfS
Mutual trust (Poulsen, 1988)	Need to overcome scepticism associated with change (Knight and Jenkins, 2009)	Faster implementation process
Collective aspirations among employees (Hasle and Srensen, 2013)	Aligning company goals with individual perceptions (Doppelt, 2003)	Better adaptive results
Feminine attitude (Hofstede, 1980)	Risk from patriarchal thinking and false sense of security (Doppelt, 2003)	More (two-way) discussion, less rigid approaches
Egalitarian approach in society (Gallie, 2003)	Fear of work overload (Verhulst and Boks, 2012)	Increase acceptance for work and responsibility changes in the firm

4.3 Perspective 3: Role of Collaborations in DfS implementation

The content presented in this Section is adapted from Ali and Boks (2017) published as part of this thesis.

Sustainability initiatives in companies necessitate involving multiple actors in the decision making process. In the case of DfS projects, this would mean the need for more information on the sustainability aspects of the product being designed, requirement of additional skill sets for product developers on environmental topics and tools, overview of guidelines and legislative requirements from governments and other organisations to be complied with etc. This in turn demands increased collaboration and close working between the different stakeholders (Hallstedt et al., 2013). Given the overall framing of this thesis on contextual factors during the implementation process, it was interesting to probe on the different collaboration practices happening in companies during DfS implementation and how adjacent literature on collaboration in a similar environment can contribute to it. The findings from this research perspective, primarily based on Ali and Boks (2017) are summarised in the Sections below.

4.3.1 Research Methodology

The research methodology used for this study is outlined in Figure 4.6. In addition to reviewing existing literature on collaboration practices in companies and the factors that influence them, I also looked into the New Product Development (NPD) as some of the features of NPD, such as need for innovation, radical improvements, multiple actors involved in the process etc. (Parker, 2000) were similar to those that can be observed during DfS implementation (McAloone et al., 2009; Prendeville et al., 2017).

In addition to this, fifteen interviews at seven case companies were used as the empirical basis for evaluating the different aspects of collaboration practices happening in companies implementing DfS. An overview of respondents and the case companies is provided in Table 4.2. The interviews lasted 60-90 minutes and the topic of collaboration was investigated in parallel to other topics addressed in Perspectives 4 and 5. The interview data was then transcribed using NVivo software. Phase I of the data analysis probed the different actors the respondents interacted with and factors that influenced the collaboration practices that existed between these actors. This coding process was based on inputs from existing literature which is summarised in Section 4.3.2. Phase II of data analysis grouped these factors in influencing and inhibiting/facilitating collaboration, summarised in Section 4.3.3.

4.3.2 Theoretical Framing

There is an existing call from researchers to focus on inter and intra firm collaborations happening in DfS implementation (McAloone and Pigosso, 2017; Prendeville et al., 2017). Such collaborations both within and beyond the company boundaries are required for effective integration of DfS (Alblas et al., 2014; Dekoninck et al., 2016), to influence

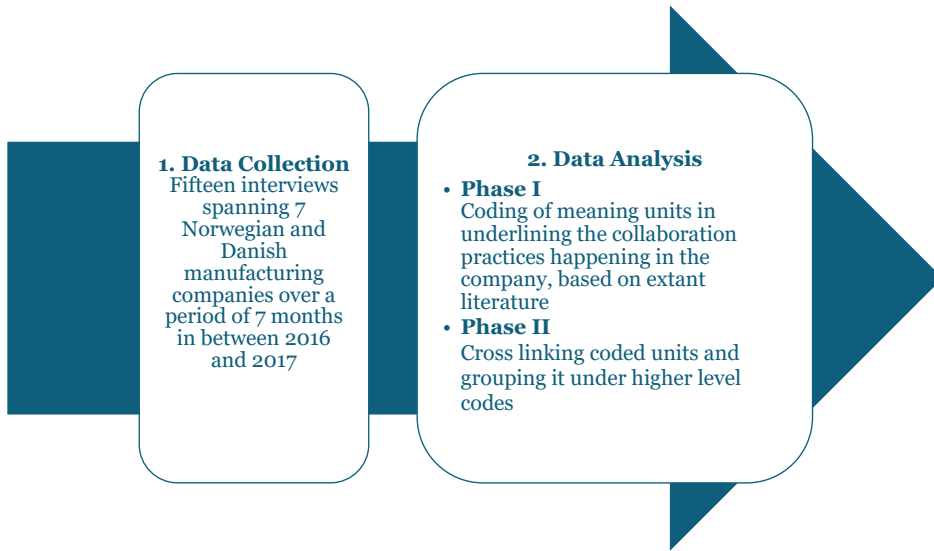


Figure 4.6: Two stage research methodology used for Perspective 3

relevant actors (Poulikidou et al., 2014) and to extend the sustainability vision of the company to the entire value chain (Brones et al., 2014). As identified from the literature review presented in Table 2.1, researchers have significantly highlighted the importance of collaboration practices in DfS setting. Nevertheless, studies exclusively on the topic collaboration in DfS implementation is scarce, specially on the factors that determine the extend and success of these collaborations.

In a similar vein, the need for collaborations in the context of new product development (NPD) has been well discussed and researched. Kahn (1996) explores the influence of interdepartmental integration in companies involved in NPD, the survey results show that increased interdepartmental collaborations, presented as a sub category of interdepartmental integration (the other sub category being interactions) between the departments showed a significant performance change in the processes and post launch follow up of the products. Collaborations between departments involved in the product development processes have shown to improve the communication, dependability and remove the uncertainty issues associated with product development processes (Kahn, 2001; Souder et al., 1998). Further, Lawton Smith et al. (1991) note that the primary motivation behind inter-firm collaboration is the mutual gain for all participating stakeholders. This gain could be in the form of technological innovations, new knowledge and skill sets or increased revenue.

Literature on the topic outlines these collaborations to involve a range of formal and informal activities that happens within the organisation. These include the regular team meetings, informal discussions on the project topics, sharing of resources both tangible and intangible, exchange of tacit knowledge etc. Collaboration activities in general relate to the joint activities between a number of departments towards achieving a common vision, complemented by a mutual understanding of the topic and collective goals (Kahn, 1996). As such activities are seldom defined within an organisation, it often requires joint

ID	Company/ Respondent Group	Industry	Major Business Region	Number of Interviews	Respondent Background
A	Pouch	Medicare supplier	Global	2	A1: EHS A2: EHS A3: PM
B	Microbes	Biotechnology	Global	1	B1: Sustainability
C	Watt	Renewable energy	Global	2	C1: EHS C2: EHS
D	Wood	Construction	Global	2	D1: Sourcing D2: Product regulations
E	Vitamin	Health care	Scandinavia	2	E1: Communications E2: Sourcing
F	Food	Consumer Goods	Global	2	F1: EHS F2: CR
G	Soap	Personal Care	Scandinavia	4	G1: R&D G2: R&D G3: R&D G4: Marketing

Table 4.2: Interview respondent details, case company background, and number of interviews for Perspective 3. EHS = Environment Health and Safety, R&D = Research & Development, CR = Corporate Responsibility, PM = Project Management

efforts, trust and interrelationship to sustain over the longer period of time. Parker (2013) also notes that clear and timely information flow between the stakeholders should also be ensured to maintain this mutual trust.

Further probing the academic discussion on interdepartmental collaborations in literature on organisations and strategic management, one can find that the applicability and need for the same has been over-emphasised in multiple scenarios. Companies involved in NPD activities with strong collaboration practices within their departments were found to be more effective and responsive to the market demands, user expectations and in resolving the engineering challenges (Oswald et al., 2012). Thus, based on the brief literature review carried out as part of this work, we can safely hypothesise that both external and internal collaborations have important role in determining the success or failure of challenging projects in companies.

4.3.3 Findings

While analysing the collected data, the first approach was to identify both internal and external collaboration practices separately. It was observed that there were some evident actors that were exclusive only to internal or external collaborations ¹ (eg. suppliers and customers in external collaboration and; R&D department and Board of Directors in internal collaborations). However, further analysis of the data showed that there was a clear overlap in list of factors that facilitate/inhibit collaborations and that influence

¹Internal collaborations - happening within the company boundary between different departments and individuals

External collaborations - with actors such as suppliers, customers, government and research organisations outside the company boundary

Facilitators/Inhibitors of Collaboration

- Common understanding surrounding DfS between collaborating actors
- Customer demand for DfS products
- Extent of independence awarded to employees/units to initiate collaboration
- Infrastructure support (eg. Co-location, technology support)
- Motivation for working closely with each other
- Position in the value chain

Influencers of Collaboration

- Organisational structure in the company
- Goodwill of the company among targeted actors
- Clarity surrounding ownership of knowledge emanating from collaboration
- Competition pressure in market and lack of resources and skills
- Management support towards involving external and internal actors
- Trust between actors and previous history of collaboration

Figure 4.7: A summary of facilitating/inhibiting and influencing factors that determine collaboration practices during DfS implementation in companies

collaboration both internally and externally. Therefore, observations under both internal and external collaborations were not analysed separately in Phase II, but rather jointly. A summary of these factors (affecting both internal and external collaborations) is presented in Figure 4.7.

As can be observed from the list in Figure 4.7, these factors are very much dependent on the company context it operates in. The first list of factors are titled as both facilitating and inhibiting because the same list of factors acted differently in different company contexts. For example, in Company A, which had a strong market presence in their sector and global scale of operation, it was easier for them to initiate collaboration with suppliers on environment friendly raw material. Whereas in the case of Company E, which was relatively a smaller company in their segment, had to follow the general trend in the market. Common understanding on sustainability topics and terminology being used was a determining factor in Company B. Being a heavily a research driven company, Company B experienced generally a higher level of understanding on sustainability topics within the company. This was also due to the structural mechanism the company had put in place to formalise sustainability within itself. Strong motivation to work on sustainability topics was another factor that made collaboration between actors easier. This was the case in Company D, who wanted to source for new materials that can replace their current raw material portfolio. This was in turn met with an increased interest from suppliers of non-conventional raw material (as they saw a business potential in it). Thus making collaboration efforts easier and swift. Co-location between different divisions was found to be conducive in realising close collaboration in Companies G and F.

In addition to these factors that facilitate or inhibit collaboration, another interesting observation was the presence of certain niche aspects of the company that influence the overall direction of collaboration. It was observed that small companies often feared to collaborate or work closely with larger firms due to the risk of being overtaken by the latter. Trust was another important factor in this list, companies/entities that have worked closely together found it easier to start of new projects compared to completely new actors. Company F had a strong pressure from their top management to co-develop

sustainable product offerings with research organisations and other actors in the market. This was due to the increasing demand for more sustainable products from their customer base and visibly better position of their competitors in the “green product” segment.

All in all, these observations were in congruence with earlier findings on the different success factors for DfS implementation (Johansson, 2002). This was also in line with observations made by ORafferty and OConnor (2010) and O Connor (2001) who studied multi-stakeholder collaboration in environmentally conscious design fields. Additionally, this research perspective also answers the call for pushing the research frontiers on managing DfS implementation by studying hitherto less addressed perspectives combining sustainability with management of processes (Brones et al., 2017). Further, it can also be observed that there is striking similarity between collaboration practices and factors affecting it in both NPD and DfS.

4.3.4 Overall contributions to this thesis

Collaboration between different stakeholders was found to be a necessity in companies dealing with sustainability topics. This was observed both in Table 2.1 and similarly in the case company interviews done as part of this Perspective. By enlisting different factors that determine the course of collaboration in DfS context, this contributes to the overall discourse on the relevance of company context being discussed in this thesis. These factors along with findings from Perspectives 1 and 2 form the basis of discussion presented in Perspectives 4 and 5, where I present two complementary approaches researchers, DfS practitioners and consultants can take to address DfS implementation challenges in companies.

4.4 Perspective 4: “Company Persona” as a tool for DfS implementation

The content presented in this Section is adapted from Ali et al. (2019) published as part of this thesis.

As stated in the preceding sections of this Chapter, Perspective 4 aimed at materialising steps design practitioners, consultants and sustainability experts can take to understand the company context better. Chapter 1 briefly touches upon on how user personas used by designers help in understanding the end user closer and better. Drawing from such studies on how user personas can be used to understand the context of the user better, this study built on empirical data from case company interviews to define a “company persona” as in user personas and the characteristics of it. The findings published in Ali et al. (ibid.) are summarised in the following paragraphs.

Based on insights from design research on user personas and combining it with the DfS implementation scenario being discussed in this thesis, this research perspective assumed that companies, as product users, possess certain characteristics that distinguish them from others; and on the other hand, there will be companies that are comparable to each other in terms of their operational internal and external contexts. Thus, this perspective set out to identify what characteristics may be relevant to distinguish companies from a DfS perspective, what dimensions they will entail, and whether and in what manner can those dimensions be identified in a comprehensive manner. Thereby, the aim was to gain insight in the feasibility of constructing ‘company personas’ from a sustainability perspective, and in the potential of eventually using these personas to facilitate choices related to which DfS tools and methods may be most suitable for that company, and how they can be implemented best. For this purpose, a company persona is tentatively defined as an archetypical set of characteristics of the company in functional, organisational, business strength and value chain dimensions that can be used to distinguish the company it is projected on from other types of companies, or enables it to be clustered with other similar companies.

4.4.1 Research Methodology

The research methodology applied in this perspective is outlined in Figure 4.8. As shown in the Figure, in addition to literature review on user personas, the data collection process also included empirical data from case companies. The following section further explains the interview process, the interviewees and the data analysis approach taken in this paper. The methodology is further detailed in Paper IV appended to this thesis.

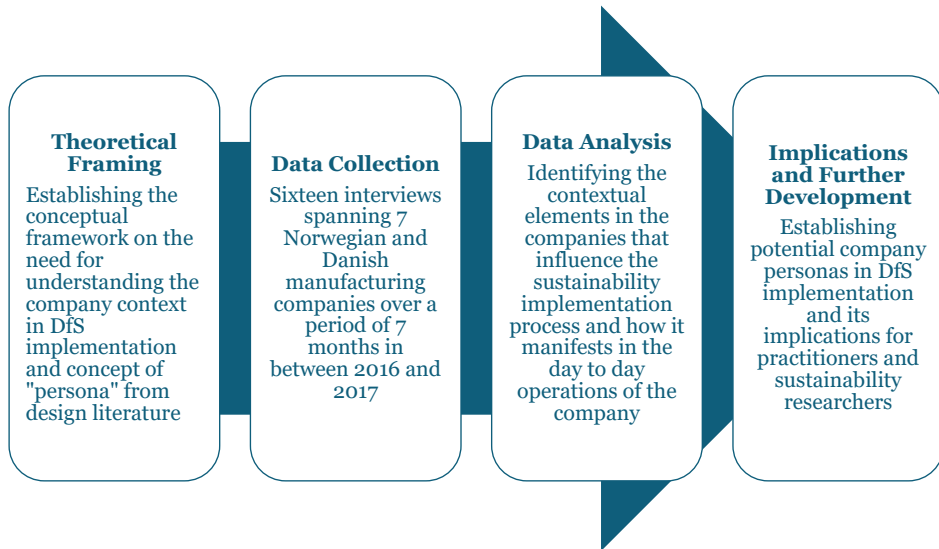


Figure 4.8: Overview of Research Methodology applied in Perspective 4

Case Interviews

The sixteen case² interviews were carried out in seven Norwegian and Danish manufacturing companies that had a sustainability focus in their in product development and clearly outlined sustainability goals in their official communication in form of annual financial and sustainability reports. Additionally, four interviews were carried out with sustainability experts in the field of Eco-design implementation for validating the findings from case companies. Among the interviewees from the case companies, seven respondents and their departments were directly involved in sustainability activities to a large extent as part of their work. Among the other departments that were represented in the interviews, product developers and project managers formed the next biggest group. The functions of other respondents varied between communication directors, EHS (Environment, Health and Safety) personnel, and R&D managers. The details of the respondents and case companies are further detailed in Table 4.3.

The interviews were aimed at corroborating the literature findings and enriching it with real case experiences of implementing sustainability strategies in the product development and how the company context influenced the overall implementation process. The semi-structured interviews lasted between 60-90 minutes and were conducted jointly with Raphaëlle Stewart (PhD counterpart in Cotutelle agreement). Further, the interview questions were aimed at eliciting insights from the respondents into how DfS was implemented in the product development activities in the company, which factors in the company context influenced the implementation process, and how interactions within the company and between the company and external actors occur on sustainability issues. In order to further complement the data collection process and enrich the information gathered from case company interviews, we used an interactive map (Figure A.2). The

²The sample group is the same as in Perspective 3, however one additional interview was done for this Perspective.

ID	Company/ Respondent Group	Industry	Major Business Region	Number of Interviews	Respondent Background
A	Pouch	Medicare supplier	Global	3	A1: EHS A2: EHS A3: PM
B	Microbes	Biotechnology	Global	1	B1: Sustainability
C	Watt	Renewable energy	Global	2	C1: EHS C2: EHS
D	Wood	Construction	Global	2	D1: Sourcing D2: Product regulations
E	Vitamin	Health care	Scandinavia	2	E1: Communications E2: Sourcing
F	Food	Consumer Goods	Global	2	F1: EHS F2: CR
G	Soap	Personal Care	Scandinavia	4	G1: R&D G2: R&D G3: R&D G4: Marketing
SE	Sustainability Experts	-	-	4	SE1: Consultant SE2: Consultant SE3: Researcher SE4: Researcher

Table 4.3: Interview respondent details, case company background, and number of interviews. EHS = Environment Health and Safety, R&D = Research & Development, CR = Corporate Responsibility, PM = Project Management

details of the map are provided in the paper.

The interviews were then transcribed using qualitative data analysis software NVivo. The interview transcripts are protected based on confidentiality agreements signed with the companies and hence are not included in this thesis as such. However, anonymous quotes from the interviews are included in the paper for validity.

4.4.2 Theoretical Framing

As the discussion surrounding persona presented in the paper is important to the summary being presented here in this thesis, the same is adapted and reproduced in the following paragraphs. The paper further discusses the importance of contextual factors in DfS implementation, which is not included here so as to avoid repetition of the detailed discussion on the same presented in Chapter 2.

Persona origin, definition and dimensions

The origin of the persona as a research topic is widely found in user centred design literature, where the user is placed in the centre of the design process. Alan Cooper while introducing persona as a method for designers in late 1990s in his seminal work titled, “The inmates are running the asylum” opined that designers often have unclear or vague ideas of the end user of the product and are most often driven by user scenarios similar

to the designer himself/herself. “Goal directed design” was suggested as an alternate approach to overcome this shortcoming. As Cooper envisaged it, such an approach included multiple user centred research methods such as interviews, ethnography etc. combined with market research, user requirements and goals to better define the user and his/her needs (Cooper, 1999). Thus for the purpose of this study, personas were defined as user classes fleshed out into “user archetype”, that gives the required precision to the design activity of the designer.

Benefits of using personas The popular support for personas come from its advantage over scenarios due to close proximity to the reality of the design goal and the engaging nature of personas (Grudin and Pruitt, 2002). Personas help design teams in thinking about users during the design process, make efficient design decisions without inappropriate generalisation, and facilitate communicating about users to various stakeholders (Faily and Flechais, 2011; Matthews et al., 2012).

In another attempt to rank the different benefits of persona using the Delphi Technique, Miaskiewicz and Kozar (2011) identify the audience focus, product requirement prioritisation and challenging wrongly conceived assumptions as some of the strong points. Further, literature also observes that the creation of personas has made communications in design environment easier and more explicit. The efficacy of driving the debate and arriving at design decisions made the technique popular among designers (Pruitt and Grudin, 2003). Political and social characteristics of users remained mostly unaddressed in earlier design cases; however, the use of personas helped in recognising and challenging such characteristics (Chapman et al., 2008; Pruitt and Grudin, 2003; Rnkk et al., 2004). Using personas helps to create an embodiment of the needs and goals of the users thus providing additional specificity and avoiding the higher level of abstraction in the definition of the user (Blomquist and Arvola, 2002).

A common application of persona tool can be observed in IT systems implementation in companies, where we could identify a predominant number of examples that tend to define the persona characteristic of the user being targeted. Rnkk et al. (2004) identify certain characteristics for a case company where persona as a design technique was used but failed to overcome the design challenge. These characteristics include the demographics of the company, the field of work, their expertise in the field, years of experience, department structure etc. The article however notes that the persona technique failed because it did not take into account the external environment of the company, stakeholders outside the company. Matthews et al. (2012) observe that despite its limitation, the power of persona as a technique lies in bringing out the “some irreconcilable differences between various design stakeholder”.

Constructing user personas for design purpose

Faily and Flechais (2011) identify three main steps in creating a persona,

1. Summarising the proposition by identifying the thematic propositions that the persona shall address.
2. Enumerating and explaining the characteristics identified for the persona.

3. And, creating detailed narratives of the persona characteristics and other supporting narratives.

Floyd et al. (2008) identify the different kinds, attributes and characteristics of personas based on existing literature and case studies. They categorise the persona technique into seven major kinds, based on the detail of description, intended purpose and what kind of data is sourced to create a persona. The first classic kind of persona identified by Floyd et al. (ibid.) is the one proposed by Alan Cooper, that relies on in-depth ethnographic research and tries to create as many initial personas as possible (Cooper, 1999). It is observed that in “Cooperian” style of personas, the initial personas developed to capture the basic understanding of user characteristics are then merged through analysis to arrive at one primary persona for each user kind. These final personas are then maintained throughout the rest of the design process and discarded at the end of the project. Floyd et al. (2008) classify these Cooperian personas into two kinds, Cooperian Initial Personas (CI) and Cooperian Final Personas (CF).

Further, the second type of persona are the massive data driven approach in creating personas as proposed by Pruitt and Grudin. The data rich approach also warrants that personas developed in such manner are then retained even after the project is completed to be used and adapted in future projects (Floyd et al., 2008; Grudin and Pruitt, 2002). The third kind of persona identified by (Floyd et al., 2008) is Sinha personas, which are data driven, primarily quantitative but less comprehensive in comparison to the other kinds (Sinha, 2003). Three additional type of personas, namely ad-hoc personas, user archetypes and marketing personas are also identified by Floyd et al. (2008). The ad-hoc persona is derived from intuition and experience of the designer but discarded after the design cycle is complete. While marketing personas are used for targeting the intended product users in marketing campaigns, the user archetypes are similar to personas, except that they are more generic and cater to a larger group of audience than designer’s extreme user personas. The user archetypes are also less precise compared to a persona, thus also qualifies with more general information.

Further, Cooper (1999) noted that each human persona has a work environment, socio-economic dimension and demographic dimension of culture, ethnicity or race to it. Pruitt and Grudin (2003) further elaborated on these by looking into a set of dimensions in the case example, this included goals, fears and aspirations of the user, market size and influence, knowledge, skills and abilities, communication, views and opinions, attitude towards the solution/product etc.

4.4.3 Findings

While analysing the interview data, the points highlighted in Table 2.2 were used as the point of departure to identify potential characteristics that would define a company persona. Based on this, 14 different dimensions for the proposed “company persona” were identified. As can be observed from Table 4.4, these dimensions were derived both deductively from the interview data and inductively from DfS implementation factors identified and stated earlier in this thesis. Drawing inspiration from philosophy and metaphysics literature, these were categorised as extrinsic and intrinsic characteristics, respectively. In philosophical studies, ascription of extrinsic characteristics to a product or entity is not entirely about the product or entity. Rather, it may well be part of

a larger context in which the product or entity exists as a part (Lewis, 1983). In the context of this thesis, this could include factors external to the company that influence the company's activities, such as product offerings, value proposition, and strategies. Contrarily, a "sentence or statement or proposition" that ascribes intrinsic properties to a product or entity is entirely about that thing (Langton and Lewis, 1998). For this thesis, this translates to the internal organisation of the company, the DfS implementation process, and the functional goals to DfS, among others.

ID	Source of Dimension	Dimension	Description
E1	Deductive	Board of Directors	The role of ownership and decision-making bodies in the company.
E2	Deductive	Value proposition of the company	The main value offered by the company through its activities, which could be consultancy, product, PSS, or service.
E3	Deductive	Drive of the company on DfS issues	The major driving factor in the company in the form of cost, Corporate Social Responsibility (CSR), legal compliance, philanthropy, or total sustainability.
E4	Inductive	Strategic focus of the company	The extent to which sustainability is part of the company's defined strategy and how it is emphasized in the decision making process in the company.
E5	Inductive	Market conditions	The market readiness, regulatory needs, demand for sustainable alternatives, existing and possible collaborations with actors in the value chain on DfS.
E6	Deductive	History of the company	The traditional business experience and values that influenced sustainability activity in the company such as existing product offerings and ownership focus on niche business areas that contribute to sustainability.
E7	Deductive	Risk sensitivity	Willingness of the company to prioritize experiments, launch DfS products, or take actions leading to sustainability goals while disrupting the status-quo.
I1	Inductive	Senior management approach to DfS	The steps taken by the senior management of the company in establishing, realizing, and supporting activities which contribute to the overall sustainability strategy of the organization.
I2	Inductive	Organizational constitution	The way the departments, personnel, and functionalities are organized within the company and DfS projects executed.
I3	Inductive	Degree of formalization in DfS implementation	The method in which DfS focused projects are conceived, planned, and implemented with or without the aid of formalized processes such as stage gate models or eco-design tools.
I4	Inductive	Sustainability understanding	Extent of sustainability awareness/perception in the company and the manner in which it is/is not being incorporated in the company's activities at both individual and group levels.

Table 4.4: Description of the dimensions identified from the interviews categorised under extrinsic and intrinsic characteristics. E = Extrinsic and I = Intrinsic.

I5	Inductive	Sustainability definition	The way sustainability is defined, communicated, and operationalized in the day-to-day activities of the company.
I6	Deductive	Functional goals in DfS	Realization of sustainability goals of the company through targeted steps (leading to direct sustainability benefits) or rather incremental improvements in activities (leading to indirect sustainability benefits).
I7	Inductive	DfS chaperoning	The anchoring and leading role that drives sustainability in the company in the form of sustainability champions and departments.

Table 4.4 *Continued*

Table 4.5 presents an overview of all these different dimensions identified from coding the interview data. Each dimension is matched against the case companies where it was found to be an influential contextual factor when it came to DfS implementation. These are marked as “x” in the table. Further, the final column of the table corroborates these findings with the inputs from sustainability experts (SE) who, based on their experiences working with companies, identified the most influential factors in a company involved in DfS implementation. As can be seen from Table 4.5, the identified dimensions have a certain level of interconnectedness among them. This is primarily because the company persona is a reflection of the company context, and the context is often dependent on factors that are important on their own, yet the context is also influenced by other factors of the company. For example, a company’s strategic focus, product offering, and company history influence its market conditions. Hence, the results presented in the following sections are an outcome of a coding process that looked for such factors, both independent and dependent, in defining the company context and should be read within this context.

ID	Dimension	Company A	Company B	Company C	Company D	Company E	Company F	Company G	Sustainability Experts
E1	Board of Directors	x	x	x	x			x	x
E2	Value proposition of the company	x		x	x	x			x
E3	Drive of the company on DFS issues	x			x	x		x	x
E4	Strategic focus of the company		x		x		x	x	
E5	Market conditions	x	x	x	x	x	x	x	x
E6	History of the company				x		x		
E7	Risk sensitivity	x	x	x	x		x		x
I1	Senior management approach to DFS	x			x	x	x	x	x
I2	Organizational constitution in DFS	x			x		x	x	
I3	Degree of formalization in DFS	x		x	x	x	x	x	x
I4	Sustainability understanding	x		x	x	x	x	x	
I5	Sustainability definition	x	x		x		x	x	
I6	Functional goals in DFS	x	x	x	x	x	x	x	x
I7	DFS chapetering	x			x	x	x	x	

Table 4.5: Overview of persona dimensions as identified as an influential factor in case companies and as experienced by sustainability experts. Dimensions that were identified to be significant in the companies DFS implementation context are marked as x. E-Extrinsic Characteristics, I-Intrinsic Characteristics

4.4.4 Overall contributions to this thesis

Based on the rich interview data from seven case companies, it could be conclusively established that companies have contextual factors that differentiate them from the other companies and simultaneously play a strong role in the overall DfS implementation process. Deriving inputs from user persona research on to this, this research perspective was able to identify 14 dimensions of company persona that should help researchers and consultants in sketching and understanding the user, in our case the company, closer and better. Furthermore, a user persona is typically based on characteristics such as the demographics of the user, fears and aspirations, needs and expectations, product use patterns among others (Cooper, 1999; Grudin and Pruitt, 2002). Similarly, the intrinsic and extrinsic characteristics observed from the empirical results can provide a similar perspective of the company. Table 4.6 shows these dimensions where a cross comparison between user persona and company persona dimensions identified is potentially evident.

Table 4.6: A proposal for mapping commonly used user persona characteristics onto company persona dimensions as identified from the interviews. E = Extrinsic Characteristics and I = Intrinsic Characteristics presented in Table 4.4 (from Ali et al. (2019))

User persona characteristics	Corresponding Company persona dimension
Demographic Dimension (Cooper, 1999; Miaskiewicz and Luxmoore, 2017)	E1, E5, E6, I1, I2
Views, attitudes and opinion (Cooper, 1999; Pruitt and Grudin, 2003)	E2, E3, E4, E7, I1, I5, I6
Emotions, fears and aspirations (Pruitt and Adlin, 2006)	E3, E7, I1, I7
Knowledge skills and capabilities (Marti and Bannon, 2009; Pruitt and Grudin, 2003)	E4, I5, I6, I7
Societal factors (Lewis, 1983)	E5, E6, I1

Constructing company personas

In order to take the discussion on company personas further, this research perspective also explored how company personas similar to user personas can be constructed. Though no single best practice for constructing user personas could be identified, a data-driven approach proposed by Miaskiewicz and Kozar (2011) to create personas was chosen. The four stages through which the company persona can be created is summarised below:

1. Firstly, create an inventory of necessary sustainability attributes of the company.
2. Secondly, characterisation of the company based on the attributes along the 14 persona dimensions.

3. Thirdly, incorporating additional inputs about the company through qualitative techniques such as interviews and action research.
4. Finally, creating the individual company personas incorporating the initially identified attributes and input from Stage 3.

While applying this four stage process to create personas of the case companies interviews, certain overlap in their intrinsic and extrinsic characteristics were observed. Based on these inputs the paper proposes four sample personas that are added in the Appendix of this thesis (see Table A.1).

Implications of company persona dimensions in understanding the context

As this thesis aims at understanding the context of the companies better, it is imperative to discuss on how these 14 dimensions contribute to the ongoing discussion presented in this thesis. These dimensions in totality help in defining a complete picture of the company's internal and external context, which have been otherwise less explicitly identified in company clustering studies such as that by Domingo et al. (2015). Some of the major takeaways are:

- Companies have certain dominating dimensions in comparison to other companies. For example, intrinsic characteristics such as senior management approach, DfS implementation approach and sustainability definition were dominating compared to other dimensions. The same goes for certain extrinsic characteristics, namely, market conditions and strategic focus of the company.
- Importance of degree of formalisation in DfS implementation processes was commonly observed in all case companies, thus validating the long standing observation from academia that the level of formalisation greatly influences the success or failure of the implementation process.
- Risk sensitivity of companies towards sustainability topics and NPD was identified as an important dimension. However, this was not so evidently discussed in the literature reviewed for this thesis. This is a significant contribution on DfS discourse as risk aversion/taking attitude of the company is greatly linked to its approach to the market and the topic of sustainability. Hence, will in turn greatly influence how consultants and researchers should deal with such companies.
- Observations made on other dimensions such as market conditions, importance of knowledge and skill sets, relatively lesser need for more tools etc. were in congruence with earlier literature of DfS studies.

Thus to summarise, Perspective 4 on exploring “company personas” was able to identify contextual factors of companies that will help designers, consultants and researchers in addressing the DfS implementation challenges from a non-technical point of view. Thereby, taking observations presented in Perspectives 1,2 and 3 further into a more practical, similar to designers using user personas. The final Perspective 5 in the following section builds on this to explore the different steps management can take to bring about the necessary changes that companies should adapt based on their personas.

4.5 Perspective 5: Four Lens management model applied to DfS implementation

The content presented in this Section is adapted from Stewart et al. (2018) published as part of this thesis.

In continuation to the results presented in the preceding sections of this Chapter, Perspective 5 explored the relevance of a general management framework proposed by Bolman and Deal (2017). The following sections summarise the major findings of Stewart et al. (2018), where I was the second author and involved in curating the study, data collection and data analysis stages. Stewart studies the application of four lens framework in other research fields more in detail in her PhD thesis. For the purpose of this thesis, only application of four lens to eco-design implementation and its results published in Stewart et al. (ibid.) are summarised here.

4.5.1 Theoretical Framing

The original aim of the framework initially proposed by Bolmann and Deal in 2008 was to pragmatically aid managers, leaders and change agents of organisations in realising the goals laid out by the organisation. For this purpose, the framework builds upon different groups of management theories that provide mutually complementary views on what the organisations are and how they function. The four lenses outlined in the framework are firstly, Structural lens that views organisation as formal structure with predefined roles, responsibilities and procedures and systems. Structural lens is primarily based on classical management theories such as scientific management theory by Taylor (1911), bureaucratic management theory by Weber (1947) and Mintzberg (1979)'s work on organisational theories. The second lens in the framework is the human lens which symbolises organisations as informal entities having fears, aspirations and needs. This lens is built upon McGregor (1960)'s Theory X and theory Y, and other similar theories that study the relationships between organisations and individuals. The third lens, called the political lens relates to the political agendas, power struggles and conflicts within the organisation. Dealing with the political skill of the managers, this lens is based on the works by Kotter (1985) and Pfeffer (1981). The fourth and final lens is called the symbolic lens that deals with habits and routines established in an organisation. The symbolic lens is derived from works on organisational culture.

Further to narrow down on how these four lenses can be put into action in an organisation, Bolman and Deal (2017) proposes four perspectives for the four lenses. Structural lens through the architect perspective, human lens through the catalyst perspective, political lens through the advocate perspective and symbolic lens through prophet perspective. The architect views the organisation as a *machine* or *factory* and design targets, organisational units, processes and coordination mechanisms in the company. Catalyst tries to see the organisation as a *family* and aims to allay their fears, aid their aspirations and cater to their needs. Advocate targets on building coalitions, negotiating between conflicting agendas and gaining power in organisation, which it perceives as a *jungle*. Prophet perspective sees the organisation as a *temple* and focuses on inspiring the individuals in the

organisation, fostering sense-making and challenging common beliefs. These four lenses and accompanying perspectives are illustrated in Figure 4.9. The framework components and accompanying actions in DfS implementation context are further detailed in Paper V appended to this thesis. Thus, it is evident that the Four lens framework is a mixture of both formal(structural) and informal (political, human and symbolic) aspects of an organisation is strongly rooted in the non-technical aspects of the organisation. Given this, the management framework by Bolman and Deal (2017) is relevant for exploring how managements can materialise concrete steps in order to realise the DfS implementation process. This is even more significant as the examples of course of action outlined in Figure 4.9 are in line with the call for focusing on the non-technical aspects of DfS implementation as highlighted in Chapters 1 and 2 of this thesis.

In the light of these observations, this perspective explored the presence of the different lenses in the seven case companies and the different course of actions that were identified in each of the companies with reference to DfS implementation. These findings are summarised in the following sections.

LENS	STRUCTURAL	HUMAN	POLITICAL	SYMBOLIC
METAPHOR OF ORGANIZATION	FACTORY OR MACHINE	FAMILY	JUNGLE	TEMPLE
PERSPECTIVE ADOPTED BY THE CHANGE AGENT	ARCHITECT	CATALYST	ADVOCATE	PROPHET
SUMMARY OF BASIC ASSUMPTIONS	<ul style="list-style-type: none"> <input type="checkbox"/> The organization exists to achieve established goals and objectives. <input type="checkbox"/> What matters is that tasks are clearly and rationally divided, defined by procedures and coordinated so that work gets done. 	<ul style="list-style-type: none"> <input type="checkbox"/> People and organizations need each other: organizations need ideas, energy, and talent; people need careers, salaries, and opportunities. <input type="checkbox"/> What matters is to align people's needs and aspirations with the organization's goals. 	<ul style="list-style-type: none"> <input type="checkbox"/> The organization is an arena where individuals and interest groups fight over resources to advance their agendas. <input type="checkbox"/> What matters is to gain power, create strong alliances and manage to secure resources and priority in agendas. 	<ul style="list-style-type: none"> <input type="checkbox"/> Organizations are chaotic, uncertain and ambiguous places where much is open to interpretation. <input type="checkbox"/> What matters is to create meaning and to understand deeply anchored aspects ruling in the organization.
EXAMPLES OF COURSES OF ACTION	<ul style="list-style-type: none"> <input type="checkbox"/> Reorganize, implement or clarify policies and procedures <input type="checkbox"/> Develop new information, budgeting, or control systems <input type="checkbox"/> Add new organizational units <input type="checkbox"/> Plan processes 	<ul style="list-style-type: none"> <input type="checkbox"/> Processes of participation and involvement (task forces, open meetings, etc.) <input type="checkbox"/> Train, coach <input type="checkbox"/> Empower <input type="checkbox"/> Address individual needs, personal aspirations 	<ul style="list-style-type: none"> <input type="checkbox"/> Bargain <input type="checkbox"/> Negotiate <input type="checkbox"/> Advocate <input type="checkbox"/> Build alliances <input type="checkbox"/> Network with other key players <input type="checkbox"/> Anticipate conflicts 	<ul style="list-style-type: none"> <input type="checkbox"/> Create or revitalize ceremonies and rituals <input type="checkbox"/> Work to develop or restate the institution's vision <input type="checkbox"/> Use heroes, stories, symbols <input type="checkbox"/> Energize, inspire

Figure 4-9: Conceptual framework around the four-lens view of organisations, adapted from Paper V. It includes for each lens a) the corresponding metaphor of organisation, b) the perspective adopted by managers, leaders, or change agents, c) the summary of underlying basic assumptions about organisations, and d) examples of associated courses of action, elaborated based on the work by Bolman and Deal (1991, 2017)

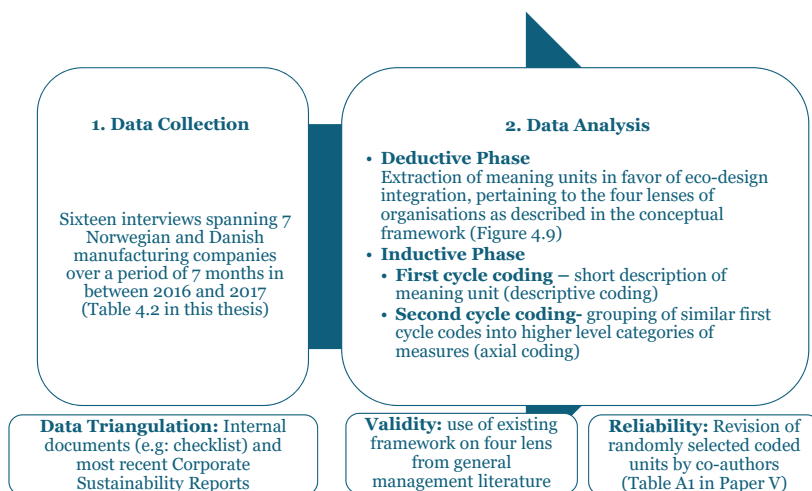


Figure 4.10: Overview of research methodology applied in Perspective 5. Adapted from Paper V

4.5.2 Research Methodology

The research methodology for this perspective is similar to Perspective 4 outlined in Section 4.4.1 and is illustrated in Figure 4.10. Semi-structured interviews lasting 60-90 minutes were used for the data collection process and was conducted together with Raphaëlle Stewart in seven case companies mentioned earlier. The details of the case companies can be found in Table 4.3. The initial focus set for the interviews was on (i) investigating how DfS has been and is being integrated in the organisation and (ii) exploring internal (across departments) and external (in the business ecosystem, e.g. with suppliers and customers) interactions around DfS³ at the company. Here, the interview transcripts were used to explore the presence of the different lenses of organisations in eco-design proponents' elaborations about eco-design integration at their company. Hence the four-lens view was used as a deductive framework to analyse the interview results and not as guide in conducting the interview in itself. Earlier studies on the application of four lens framework have also taken a similar approach (e.g: Farrell (2003) and Lief and Albert (2010)).

In addition to the interview data, Corporate Sustainability reports from the companies were also analysed for insights on different actions the companies have taken and the potential lenses those actions could be identified with. These reports also helped in understanding the sustainability vision of the company, the eco-design projects it is currently undertaking and KPIs and targets it has set in these projects with respect to sustainability. It must be observed that these factors probed for in the CS reports are prima facie from the architect's perspective. This is because Thijssens et al. (2016) have observed that probe on other perspectives in such reports yielded poor result.

Further, as shown in Figure 4.10, the interview data was analysed both inductively and

³Terms DfS and eco-design are intermittently used in the context of this Perspective, and is meant to mean one and the same

deductively to identify measures taken by companies in the light of different lenses. Inductive phase of analysis grouped these measures to higher level categories. An overview of these higher level categories and its presence across the case companies is presented in Table 4.7. The results were further analysed for cross-lens effect and the trend of dominance of certain lenses over the others in companies. These findings are summarised in the following section.

4.5.3 Findings

Lens Presence

As can be seen from Table 4.7, the architect's perspective had the largest presence among the interviewed companies. This was followed by advocate's and catalyst's perspectives respectively. Prophet's perspective was found to be least present in the interview responses. A more detailed overview of the lens presence can be found in Table A2 of Paper V. It should however be noted that architect lens could be more prominent as it focuses on measures towards formal integration, which was also the major focus of the interview questions. This potential bias is discussed in Paper V.

The interview quotes based on which these measures were derived from is detailed in the Paper. Further, Table A.2 presents a combined and detailed list of these measures extracted both from the interview data and additional literature reviewed by Stewart. To give the reader an impression of these measures, for example under the architect's perspective, measures such as "setting goals/targets", "integrating eco-design early in the PDP", "need for product design strategy along with the overall sustainability strategy" etc. were some. While in the catalyst's perspective, these were to "support or chaperon activities around sustainability in various departments". Prophet's perspective had responses like "managing the truths/ beliefs on sustainability issues in the company". Steps to "create alignment in business and sustainability measures" and "prioritisation of sustainability issues" were identified under advocate's perspective.

Companies reflected upon the presence or absence of these different measures in their departments and companies. At Company B the presence of a top-down strategy was presented as an enabler for developing sustainable products. While in another example of architect's perspective companies A and D mentioned the use of Life Cycle Analysis (LCA) has a means to achieve systematic implementation, however the use of LCAs were not strictly ensured in Company D. At Company C one of the respondents mentioned about steps taken to cater to the needs and aspirations of the employees working with sustainability, reflecting the catalyst perspective. Thus, all these measures identified from the interviews can be related to the differing contexts that exist in the companies. This further underlines the focus of this thesis.

At the respondent level, there was also a variation in the different lenses identified from different respondents from the same company. Measures mentioned by the eco-design proponents from all the companies could be related to at least three of the four lenses in all cases, and all four lenses in more than 50% of the respondents.

	Company A	Company B	Company C	Company D	Company E	Company F	Company G	No. Of companies
MEASURES								
Architect's perspective								
Integrate ecodesign procedure in product development process	H	H	H	H	N	N	N	7
Acquire/develop tools for decision-making	H	H	H	H	H	H	H	6
Design strategy related to products		H	H	N	N		N	5
Set directions/goals/targets		H		N	N	N	N	5
Develop guidelines related to product development					H	H		2
Formally define "sustainability" (e.g. standard, criteria)				H		N		2
Translate strategy into action plan for specific business units/functions					H		N	2
Translate corporate targets into targets for individual innovation projects		N						1
Create sustainability roles				H				1
Set up new KPIs					H			1
Use a process with more experimental approach						H	H	1
Catalyst's perspective								
Support/chaperon initiatives	H		H	H	H			4
Increase comfort of people to work with the topic of ecodesign		N	H		H			3
Build individual awareness of impact of decisions	H			N				2
Leverage people's aspirations	H		H					2
Participative approach to adapt the product development process		H	H					2
Frame ecodesign challenges in familiar terms			H					1
Give autonomy					H			1
Trigger people/"plant seeds"	H							1
Advocate's perspective								
Align with business/stakeholders' agenda	H	H	H		H	H	N	6
Negotiate prioritization of ecodesign in agendas	N			H	H		N	4
Emphasize criticality/emergency for business	N			H	H			3

Table 4.7: Results from the second-cycle coding grouping measures to higher level categories (from Paper V). For each lens, mentioned measures in favour of eco-design integration were mapped against the case companies. H = indicated as happening at least to some extent in the organisation; N = indicated as lacking and needed; KPI = Key Performance Indicator

Cross-Lens Effect

Influence of structural factors on architect, prophet and advocate perspectives In several cases, measures from an advocate’s, catalyst’s or prophet’s perspective seemed to develop in the absence of an architect’s approach at the company. For instance, Interviewee F1 reported that, so far, the inclusion of environmental criteria in product development had been “mostly about convincing the right people” (advocate’s perspective). At Company E, both interviewees indicated the absence of procedures for eco-design in innovation processes and reported that their work is much about supporting and chaperoning companies which are eager to act and that their approach should not give the impression to “dictate” managers (catalyst’s perspective). Interviewee D2 reported that she recurrently seeks to bring-in the focus on sustainability aspects in her presentations to senior managers (prophet’s perspective), in a context where no specific direction or target come from a top-down perspective for product development. While in other companies such as E and G, respondents commented on the need to have measures under architect’s perspective to realise different structural factors such as strategy, guidelines and organisational restructuring surrounding sustainability.

Stronger presence of architect’s perspective Given the dominating presence of measures under the architect’s perspective, it was also observed how it influence other three perspectives in companies. For example, integrating sustainability into the company and prioritising it meant more resource allocation for similar topics, as in Company G (political lens). Similarly in Company E, establishing a sustainability strategy positively influenced the power eco-design proponents yielded in PD meetings. At Company A having a more structured approach to DfS implementation meant that it was part of the daily routine in the company’s PDP.

Prophet and Catalyst perspectives in the overall implementation process As mentioned earlier, measures under prophet and catalyst were most commonly mentioned, second to architect’s perspective. Measures pertaining to prophet’s perspective helped companies A and D in promoting eco-design project in the companies. Prominence to take a scientific approach backed by experiments and data in both these companies helped in putting sustainability on the overall agenda. The presence of a company culture that promoted experimentation was the determining factor in this case.

4.5.4 Overall contributions to this thesis

All in all, the four different lenses under the general management framework by Bolman and Deal (2017) and accompanying four perspectives were explored in the context of eco-design implementation in companies. Different measures under each of these perspectives were listed based on interview data. This was further complemented by additional measures identified from a literature review done by Stewart (Table A.2). The major takeaways are:

- Architect perspective was found to be necessary to set the stage for integrating eco-design practices in PDP and for supporting the implementation process in companies.

- Prophet, catalyst and advocate perspectives were found to complement the architect perspective and vice-versa.
- Measures enlisted under prophet's perspective was found to facilitate a change in perception towards and sustainability topics and increase it's overall acceptance in companies.
- The depth and breadth of each lens and its presence in a company was significantly influence by its context.

Thus, these measures conclusively contribute to the ongoing discourse presented in this PhD thesis in two ways, firstly, it highlights the importance of understanding the company context to implement DfS successfully. Secondly, it completes the discussion presented in the four earlier Perspectives by proposing measures that companies can take based on the different contextual factors (that were explored in Perspectives 1,2,3 and 4).

4.6 The five Perspectives - a conclusion

As outlined at the onset of this Chapter, five different research Perspectives to answer the Research Questions in Section 1.2 were designed and executed. Perspectives 1,2 and 3 were exploratory in nature and unearthed factors that influence DfS implementation process in companies based on learning from adjacent literature (project management, 'Nordic' organisational culture and collaboration practices in companies respectively). Perspective 4 and 5 took these observations one step further in proposing two complementary approaches that consultants, researchers and designers can take to improve the DfS implementation process in companies. Perspective 4 used insights from user personas to propose 14 dimensions that would entail a company persona and how these dimensions categorised into intrinsic and extrinsic can help understand the niche character of companies. Perspective 5 on the other hand, builds on four lens management framework to identify different measures eco-design proponents can take to realise sustainability goals in companies. While the company persona can present a close in depth view of the company in focus, four lens framework lays down measures to deal with DfS implementation challenges in such a persona. An illustration of the overall findings of this Chapter is shown in Figure 4.11.

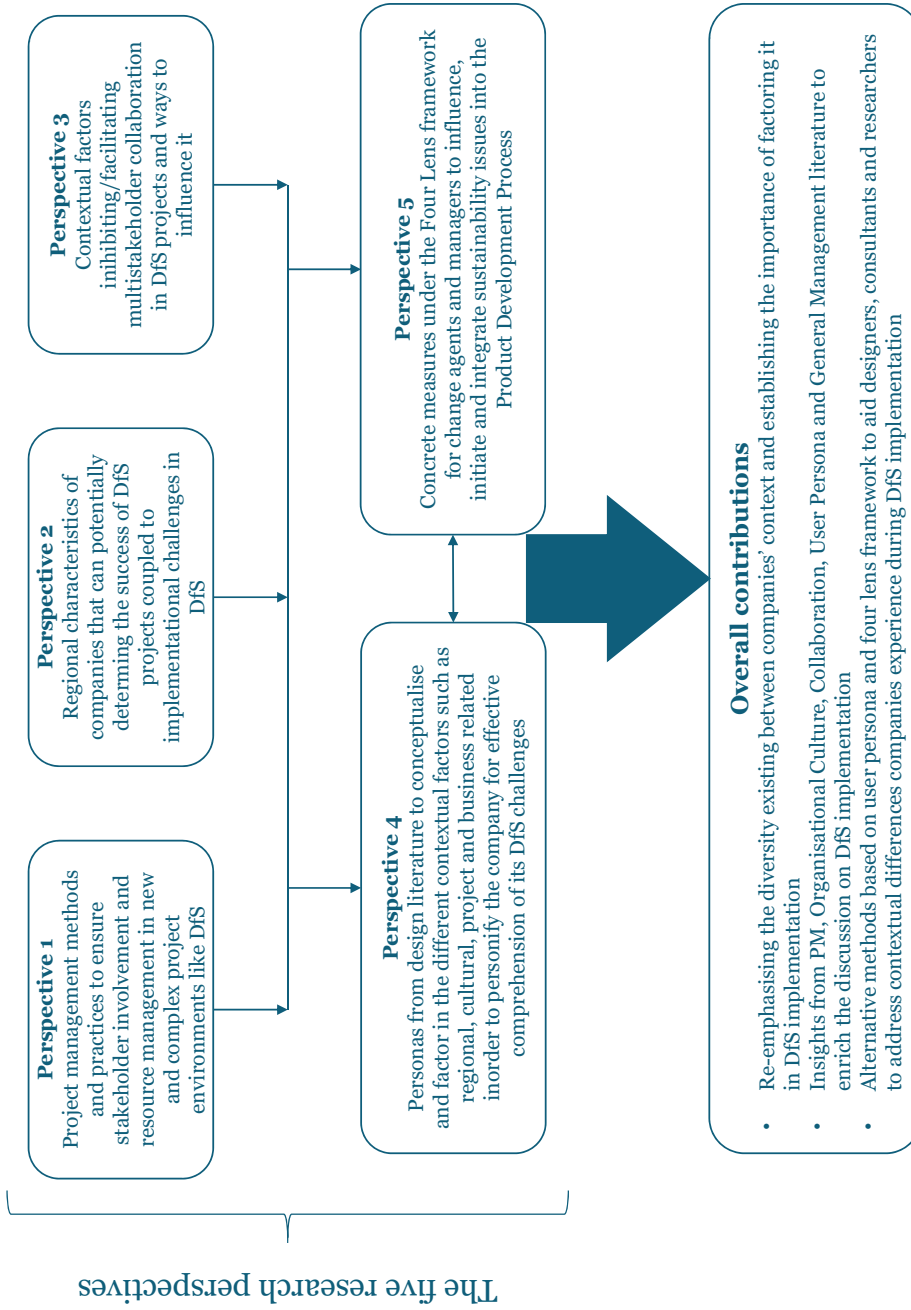


Figure 4.11: An overview of findings from the five Research Perspectives

The findings presented in this Chapter are corroborated with the Research Questions in the Chapter 5 and discussed in relation to the challenges this thesis had identified in Chapters 1 and 2.

CONCLUSION

This chapter summarises the major findings from the five different perspectives presented in the Chapter 4. This chapter begins with revisiting the research questions outlined in Section 1.2 and discusses how the different perspectives presented answer these questions. This is followed by the major contributions put forward by this thesis to the ongoing academic discourse on DfS implementation. The chapter concludes by outlining the limitations experienced in the course of this thesis and potential future work on the findings presented.

5.1 Revisiting the Research Questions

At the onset of this PhD research work, challenges faced during DfS implementation were the main focus, which were further narrowed down to the factors creating these challenges in the implementation process. The extant literature reviewed in Chapter 2 aimed at highlighting the importance of company context in DfS implementation. In order to materialise it the following overarching research question was defined in Section 1.2.

How can sustainability researchers and design practitioners be assisted in understanding the context of a company better in-order to arrive at a more tailored solution to overcome DfS implementation challenges in different industries?

This research question was further broken down into three sub-research questions to explore the different dimensions of the research objective. Chapter 2 explained the theoretical background on the motivation behind this objective and outlined the different potential research domains in Figure 2.5.

RQ1: What adjacent fields of research can positively contribute to the ongoing academic discussion on contextual challenges in DfS implementation?

Given the dynamic nature of DfS implementation and the burgeoning interest on the topic of integrating sustainability in PDP, this research question was aimed at exploring the potential insights from adjacent research fields dealing with the implementation process and the contextual factors influencing it. This was particularly interesting to explore given the relatively dynamic nature of sustainability topics in research and practice. Sustainability focus in industries are still being refined and newer domains identified on an ongoing basis. Thus making it challenging to propose one best practice at this stage of academic discourse, whereas research work on project implementation in other domains has been able to establish such best practices based on years of research and industrial insights. Therefore, the five different perspectives presented in Chapter 4 conclusively answers this research question by drawing from adjacent fields of literature that have not been widely explored in the context of DfS.

Perspective one presented in Section 4.1 explored the potential learning from Project Management (PM) literature that can be transferred to DfS implementation scenarios in industries. Product development in companies is increasingly becoming project based and project management practices are a well established field of study in industries. However, the findings presented in Section 4.1 show that studies on DfS have not yet delved into the project management aspects in sustainability focussed projects. A few existing studies on this topic were identified which highlighted a similar absence of focus on project management practices in eco-design/DfS studies (Brones et al., 2014; Pigosso and Rozenfeld, 2011). Similarly, though no specific articles on PM delving into DfS could be identified, the study showed that PM literature has proposed steps to manage projects dealing with environmental topics in general. Thus, the PM literature reviewed and compared with the DfS implementation challenges showed that companies' insights from resource management, human interactions, project control and success factor definition in projects are interesting arenas that can contribute to the ongoing discourse DfS implementation literature. A list of tools and techniques prescribed by PMBoK to include these organisational factors in project implementation was identified and presented in Perspective 4.1.

The second perspective presented as part of this thesis explored the influence of a cultural setting on sustainability implementation in companies. Given the geographical setting of this study in Norway and Denmark and the fact that most Scandinavian companies seem to perform well on sustainability topics (Emmelin, 1998; Lindell and Karagozoglu, 2001), it was interesting to explore the influence of the Nordic Culture on the sustainability activity in the region. Nordic countries are touted to be more egalitarian and feminine in approach (Hofstede, 1983) enabling the companies in the region to maintain a flat and balanced organisational structure. The major findings from the study presented in Section 4.2 indicate that the general socio-cultural setting in Scandinavian companies provide an environment favourable for sustainability implementation. Factors such as flat organisational structure, better gender balance in companies and participatory decision making were identified as some of the preferred organisational characteristics in a DfS implementation milieu. However, the study also noted that despite these characteristics the level of implementation is below the desired target level and most of the research papers coming from the region point towards an existing potential to improve the uptake of DfS in industries. Nevertheless, the insights presented from the study provides more conclusive evidence on the relevance of the socio-cultural context of a company involved in DfS projects. Understanding these cultural intricacies will help define the non-technical needs of the company closer and better.

Perspective 3 was designed with an aim to address an evident call from researchers to emphasise on the importance of collaboration with different stakeholders during DfS implementation (McAloone and Pigosso, 2017; Poulikidou et al., 2014; Prendeville et al., 2017). Various factors affecting collaboration were studied based on interviews in 7 case companies. Further, a list of these factors that can be attributed to the overall context of the company was identified and listed in Section 4.3.3. Identification of these factors were though both inductive and deductive approach, where the latter approach helped in coding for factors that affected both internal and external collaborations in the company, while the inductive approach based on inputs from collaboration literature in NPD helped in aggregating these codes to higher level meaningful groups. Thereby, Perspective 3 answers this research question in two ways (i) establishes the relevance of using findings from NPD (a field clearly adjacent to DfS) in order to explore the factors of collaboration practices, (ii) by connecting these identified factors to the context of the company, flags various hot-spots that need attention while addressing the non-technical challenges in DfS implementation.

The fourth perspective explored the idea of “company personas” as in user personas from design literature and the extent to which company characteristics can be extracted from empirical data to define a “company persona” comprehensively from a sustainability perspective. Extracting insights from design literature on how designers use the concept of personas to better elicit information about the needs, aspirations and expectations of the user and thereby design solutions catering to it, the study found that a similar approach can be established for companies involved in DfS implementation by defining their characteristics that sustainability consultants and researchers should look into. Further, personas are used by designers to enrich their understanding of the end user in a real case scenario, thereby closing the gap between designers and actual users, a challenge that Boks (2006) also raises while studying eco-design in Asian companies. Thus by encouraging researchers, consultants and DfS proponents to consider companies as end users of their consultancy or research results, and thereby using design methodologies such as personas to understand the context better, the domain of DfS research enriches itself by placing closer to the actual needs of the company and overcome the challenges posed by standardised solutions.

The final research perspective presented in Chapter 4 is based on a general management model by Bolman and Deal (2017) that presents four lenses of management approaches to help managers and change agents in companies. The four-lens view of organisations groups various management theories and build upon it to understand the diverse roles in an organisational setting of a company. The structural, human, political and symbolic lenses elaborated in Chapter 4 relate to the relevance of various propositions proponents of DfS in companies have to take and thereby adopt steps to overcome the managerial and organisational challenges in the implementation process. Insights on various steps under each of the four lenses compliment the earlier findings from DfS literature that air the need for more concrete steps on the managerial front and accompanying transition in DfS projects.

All in all, the aim of this research question was to identify the relevant fields of research that can be placed adjacent to the one on DfS implementation, and thereby map the possible learning points that can benefit the overall DfS implementation process. Given that there are still unaddressed challenges in DfS implementation and DfS uptake by industry is still found low, it was interesting to see how other adjacent fields matured through

this stage and how that maturing process can contribute to DfS. Thus, by exploring five such research perspectives and its potential contributions to this PhD's topic, this thesis has successfully identified and established that the overall discourse on DfS is poised to benefit from adjacent fields that have been researched and studied far more in depth, and conclusively these five research perspectives are a piquant addition to that list of fields.

RQ2: How do the external and internal environments of a company's organisational setting influence its internal sustainability practices and perceptions?

This research question was addressed in four of the five research perspectives. The 'Nordic Approach' focussed on understanding the socio-cultural setting in Scandinavia and how it influences sustainability uptake in the region. The collaboration perspective addressed the various collaboration practices occurring within and beyond the company boundary, the factors influencing it and facilitating the collaboration. The fourth perspective in Chapter 4 explored the concept of "company personas", in the course of which both the extrinsic and intrinsic characteristics of a company was explored. The final perspective on the four lens management framework and its relevance in supporting transitions in companies using four lenses in an eco-design context primarily highlights the different steps managers and change agents can take to facilitate the transition from established PD processes. Based on these observations, the findings are mainly twofold:

1. The internal and external environments of the company have a strong and clear influence on the company's sustainability initiatives in product development. As discussed in Sections 4.4 and 4.5 factors such as market conditions, cultural setting of the company (external) and sustainability strategy, organisational structure (internal environment) were both found to have an impact on the decisions companies take during DfS implementation.
2. The intra-organisational factors such as strategy, senior management support, culture conducive for sustainability and concrete steps to mitigate the managerial challenges were identified as crucial and necessary in companies.

RQ3: How can the niche characteristics of the company be explored and understood better to arrive at customised solutions for organisational challenges in DfS implementation?

The aim behind designing this research question was to propose an answer to the oft-identified challenge of using standardised solutions in DfS implementation. As mentioned in the earlier Chapters of this thesis, it is an established fact that sustainability needs of companies differ from each other and "one-size fits all" solutions do not often provide the best/desired results in companies. Based on this understanding, the last two perspectives explored in this thesis, namely, Company personas used insights from design literature, while the Four lens model, based on the general management framework by Bolman and Deal (2017), proposed steps that companies can take to identify the context and also support the transition towards DfS implementation.

In the context of company personas, based on empirical data from seven Norwegian and Danish companies two major set of characteristics were identified, namely, extrinsic and intrinsic. Extrinsic characteristics relate to the factors that are influenced by a company's external interactions and entities in the larger context where a company exists. Intrinsic characteristics on the other hand relate to factors pertaining entirely to the company and its internal happenings. These two set of characteristics were further granulated based

on 14 persona dimensions identified based on the 20 interviews carried out as part of the study. These dimensions are in concurrence with existing findings on organisational factors in DfS implementation, while at the same time also builds upon it by highlighting the importance of certain less addressed factors such as risk sensitivity of the companies and the presence of strong interconnectedness between various contextual factors in the company. Thus, the study thereby proposed that such an approach to understand the context of a company will help in placing the researcher or consultant closer to the company and thereby aid in prescribing more effective solutions in comparison to standardised solutions.

The fifth perspective on Four lenses proposed measures for managers and eco-design proponents in companies to integrate sustainability in the PDP by taking four different roles of architect, catalyst, advocate and prophet. The four roles placed departments and individuals involved in eco-design implementation process under four different managerial perspectives or lenses, namely, structural, human, political and symbolic to identify the potential steps that can be taken to facilitate the transition towards eco-design integration. The findings were in concurrence with existing research that the structural lens, thereby the architect, has a predominantly influential role in realising sustainability goals in PDP. This mainly revolved around setting KPIs, specific targets, guidance on proceeding towards the set strategy of the company among others. The measures identified under the catalyst role focussed on unearthing steps to support the overall implementation process through participative approach and maximum constructive involvement from concerned stakeholders. Whereas the political lens, or the advocate's role, enlisted the importance of creating a consensus among the stakeholders in the implementation process and steps achieve such an alignment in expectations and needs. Symbolic, the fourth lens, was found to have a comparatively lower relevance among the four lenses. Measures proposed included creating better clarity and awareness surrounding DfS projects and the importance of clear demarcation of responsibilities during the implementation process. To summarise, the four lenses and accompanying roles thereby identified concrete measures that can be used to support a company by addressing its various managerial challenges.

5.2 Major Contributions

To summarise, as observed in Chapter 1 the overall research field of Design for Sustainability implementation in companies has been undergoing a gradual shift over the last 25 years. Emerging from end-of-pipe solutions to compact the environmental impact of product development processes, the field has seen an emergence of adjacent literature from the management, environmental assessments, industrial ecology and business studies to enlarge the focus and thereby encompass complete sustainability surrounding products' life-cycle. One of the latest entrant to this ongoing discourse has been Design for Sustainability that has formed the focal point of this PhD thesis. Building upon this, the major contributions of this thesis are fourfold,

1. The potential of learning and adapting insights from adjacent research fields to improve DfS implementation process in companies is scientifically presented. Five different well established research fields are explored and their relevance is established backed by empirical data.

2. In response to the call from academia to focus on non-technical aspect of DfS implementation, this thesis expands on already known organisational factors, identify new ones and establish approaches to address them. Thereby underlining the importance of company context in overall DfS implementation.
3. Practical insights from personas and the four lens framework to help sustainability researchers, practitioners and consultants to better understand the company context and thereby take a customised approach suitable for each company involved in DfS projects. This opens up new dimensions on DfS discourse that has been primarily driven by tool development.
4. Empirically rich and qualitatively in depth data on companies which is often found lacking in current literature. The interview transcripts produced as part of this PhD can be used as reference material by researchers working on this field, thus contributing to open research.

Further, based on the three research questions, the answers to it presented in the preceding section and the research perspectives of this PhD thesis summarised in Chapter 4, one can clearly observe that the major contribution of this thesis has been to add on to the ongoing discourse on DfS implementation. An illustration of this evolution is provided in Figure 5.1, where the significant work from researchers working on DfS/eco-design implementation in companies are presented along the timeline. For easy comprehension and to highlight the most recent steps, the timeline includes only research articles since the last decade. As can be seen from the figure, the contributions from this PhD thesis follows the ongoing trend in the field, where it broadens to include and learn from relevant adjacent fields of study. Therefore, this PhD thesis places itself at this stage of broadening research focus. As the field develops and includes multidisciplinary it is presumed that the focus will gradually narrow down to a more matured approach to DfS implementation in companies as illustrated by the diagonal arrows in the figure. The intention behind selecting the five research perspectives presented in Chapter 4 was not to restrict the domain to these five studies, but rather to highlight the potential of such a multidisciplinary research to build on to the existing literature on the topic of DfS implementation.

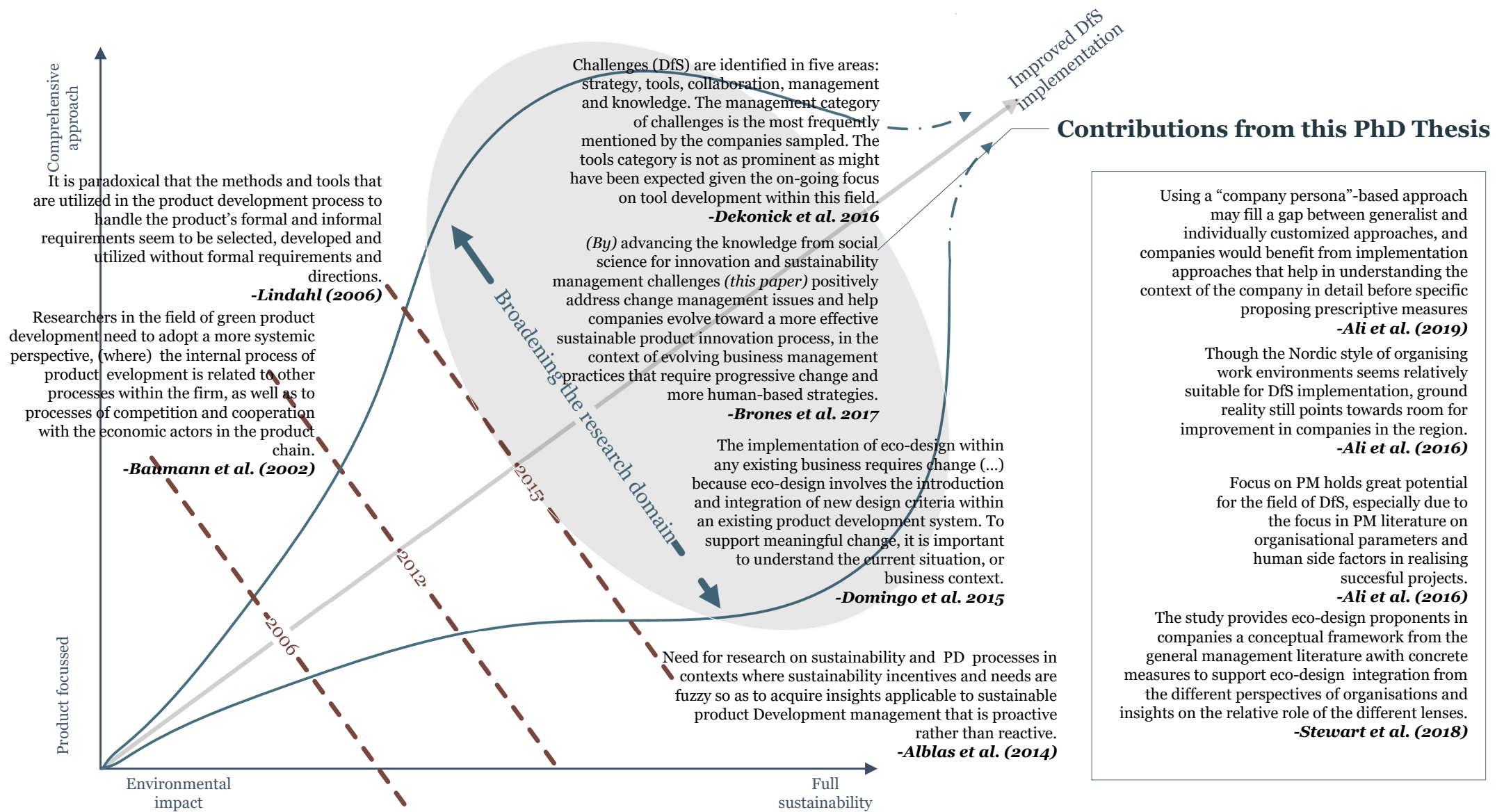


Figure 5.1: Contributions from this PhD Thesis along the evolution of Design for Sustainability. Quotes from some of the significant contributions to this field of research over the years are presented along the time-line. The contributions from this PhD thesis are mapped onto this evolution in the top-right corner.

5.3 Directions for future work

This PhD thesis will not be complete without addressing the limitations and uncertainties experienced during the course of this project. The thesis is built on rich empirical data spanning research articles, in depth and extensive interviews with companies from different fields, feedback from research fraternity at numerous conferences and seminars and validation rounds with sustainability experts on the findings. Nevertheless, the primary limitation is the lack of extensive field data that on validating some of the findings, namely, the persona characteristics of a company and the measures proposed under four lenses in a real case setting.

Therefore, one of the future research directions can include the testing of the research proposal put forth in thesis in a real case scenario involving companies with sustainability focussed product design and researchers/consultants/DfS proponents mitigating the implementation challenges.

Further, the study on the influence of ‘Nordic Approach’ on sustainability implementation highlights certain interesting and conducive aspects of Scandinavia that should favour the overall uptake of sustainability in product development. However, as identified in Section 4.2 companies in the region still struggle to cope with certain implementation challenges most of which are also organisational or managerial in nature. Therefore, it would be interesting from a research perspective to find the reasons behind this disconnect based on detailed studies in the companies.

Finally, despite being rich in insights and explanation, qualitative data is often challenging to collect and analyse within a short span of time. This is mainly due to the time it demands to establish contacts, build trust and to immerse the researcher in the setting. Therefore, a research design with a closer interaction with a few selected case companies will add on to the value presented in this thesis.

5.4 Recommendations from this thesis

5.4.1 Not another DfS tool

While concluding this PhD thesis, I would like to add a note on why this thesis predominantly took a descriptive approach on the topic of DfS implementation and does not propose another DfS tool/method. This was a conscious choice made at the start of this PhD, primarily, due to the already long list of eco-design tools, methods and approaches prescribed by the academia, of which only a few are being actively used by companies and even fewer ones yielding the desired results. Rather, it questions the role and relevance of such tools, by explaining the complexity of the subject at hand by broadening the perspective. Secondly, before embarking on this PhD journey, it was hypothesised and later established to a large extent (based on the five perspectives) that it is not necessarily new/additional tools that companies need to realise sustainability goals in product development, rather solutions that are relevant for them. By relevance I mean interventions to influence the way sustainability is managed in the company or mapping the hot-spots (in the form of low employee motivation or power struggles between departments) that was

impeding the whole implementation process. Exploring and understanding this relevance has been primarily the goal of this thesis.

By bringing in insights from adjacent fields and by leading the discussion of transferring these insights to DfS scenario, this thesis aimed at widening the ongoing discourse surrounding DfS. These inputs can in turn help consultants, designers and researchers to approach companies in a more informed manner, i.e. persona descriptions can bring forward intricacies (such as risk sensitivity, power struggles etc.) of the company that may be overlooked in a conventional approach to DfS implementation. While, measures enlisted under architect lens of the four lens framework can be used to formalise and streamline the implementation process, decide upon the nature of the tool needed, departments or units to be involved in the process etc. Further, given the complexity of the subject as established by this thesis and extant literature in the field of DfS, it would be premature to suggest one best practice for improving the implementation process. Therefore, the biggest value proposition of this thesis is not another DfS tool, rather, this thesis sets the ground to facilitate and encourage discussion for eco-design proponents to identify contextual factors relevant for their case/company and thereby materialise it in the best way suitable for their respective contexts.

Further, based on these observations and discussion presented in the preceding sections, I would like to put forward a set of recommendations to the target audience of this PhD thesis. These recommendations are as following.

5.4.2 Researchers and Consultants

Academic proponents of DfS and consultants working towards improved DfS implementation in companies constitute the largest group of the target audience for this thesis. There are mainly two reasons for it, firstly, researchers and consultants have been at the forefront of driving DfS implementation in companies through tool development and exploratory studies. Secondly, the descriptive nature of this thesis makes it an interesting proposition to be built upon further for researchers working on the topic.

Taking the findings of this thesis a step further, it is recommended that tool and method development for DfS implementation henceforth should have elements that address the non-technical aspects of the company that have been highlighted in this thesis. Further, the 14 company persona dimensions and measures under four lenses can be widely applied in understanding companies closer and better. Such definitions will provide the required depth and clarity regarding the real picture on DfS implementation in companies. Getting this clear picture is often a challenge in consultancies, specially as most consultants work within a restricted time frame, that limits their ability to get closer to the case company. Additionally, given the generic nature of the findings presented in this thesis, it is also possible to translate them into other similar contexts without losing its application value. The rich qualitative data from seven companies collected as part of this thesis can also be used by researchers in improving the field of DfS research further. This is all the more important given the time and effort required to conduct qualitative research, both of which are scarce and demanding in dynamic research environments.

5.4.3 Design Practitioners and Company Management

The second group of benefactors, though relatively less significant than the first group, are designers developing sustainability focussed products and companies using solutions from target group mentioned in Section 5.4.2. Design practitioners and company management struggling with DfS implementation can use the findings presented in this as means for self reflection to guide their steps in mitigating the implementation challenges. It can be assumed that the coupling points between DfS and PM, DfS and regional characteristics and the effect of different collaboration practices can provide insightful learning points to companies on how to deal with these three topics. While on the other hand, descriptions of 14 persona dimensions identified and the descriptive measures listed under four lenses can be used by DfS proponents to improve the implementation process. Though as identified in Section 5.3 there is a need for further fine tuning of these dimensions and measures.

Thus to conclude, conventional research on DfS implementation has been characterised by standardised solutions and tool development to aid DfS proponents. Contrary to that, this PhD thesis explored the topic of company context with an aim to improve overall DfS implementation. The descriptive findings presented along with it assimilates findings from five research domains that was found to be valuable for both researchers and practitioners on the topic.

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APPENDIX

	Barriers and challenges identified from DfS implementation literature														
	Empowerment (Verhulst & Boks, 2012)	Lack of effective and continuous communication	Need for creativity	Need for innovation/Continuous Improvement	Individual perception incompatible with company goals	Resistance to change	Insufficient stakeholder involvement (Bainmann et al.)	Cultural diversity existing in the implementation environment	Lack of awareness of the sustainability implementation strategy of the company	Steeper learning curve for individuals involved	Fear of additional workload	Lack of support by senior management (Verhulst & Boks, 2012)	Parochial thinking leading to a false sense of security (Doppelt, 2003)	Scepticism on potential benefits from sustainability focus	Language barriers
Flat organisational structure															
Collective aspirations among employees (Haak and Sorensen, 2013)															
Individualistic behaviour (Haak and Sorensen, 2013)															
High degree of stakeholder approach (Lindell & Aronson 1996)															
Lower conflict occurrence															
High uncertainty avoidance															
Proper planning and order															
Weak task orientation															
Strong employee orientation by management															
Innovation driven															
Mutual trust between employees															
Formalism with a paternalistic approach in society (Giddens, 1986)															

Figure A.1: Nordic factors identified from literature mapped onto barriers in DfS implementation. Colour coding denotes how the Nordic factors can potentially facilitate, hinder or be conducive and impeding depending on the context, during the implementation process. **Legend:** Green = The Nordic approach characteristic will help in overcoming the challenge, Yellow = No clear connection can be established based on existing literature, based on deductions from the literature, Red = The Nordic approach characteristic will aggravate the challenge, Gradient = The Nordic factor can be both conducive and impeding, based on deductions from the literature

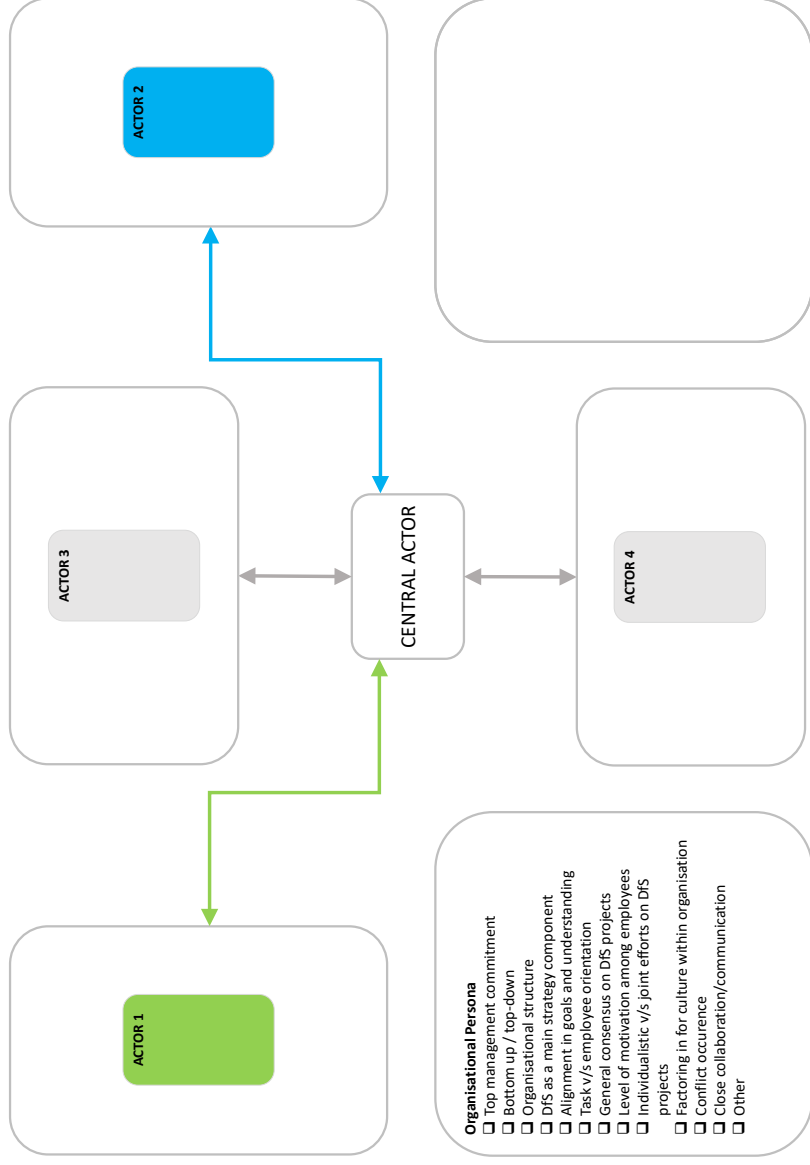


Figure A.2: Interaction mapper used to enrich the data collection process during case company interviews. The central actor was the interview respondent. The map was used to identify the various contextual elements of the company in relation to DFS implementation and different actors the respondent interacted with.

Table A.1: Persona samples extracted from case company interviews. PD = Product Development, R&D = Research and Development, CE = Circular Economy, B2B= Business to Business (from Ali et al. (2019))

Persona #	Persona Description
Persona 1 (<i>Wood, Watt</i>)	The company is a market leader in its industry branch with a high price and efficiency focused customer base. The company acknowledges the need for sustainability in its PD, however also identifies the indirect sustainability benefits from its product as a contribution to this. PD is very well formalized, nevertheless DfS tools are not used consistently and regularly. Certain customers request the company to provide environmental information which along with other compliance requirements are adhered to. Lack of both an exclusive sustainability department and market demand are two major challenges. The company aims at providing DfS solutions with increased efficiency and develop CE business models.
Persona 2 (<i>Food, Soap, Vitamin</i>)	A highly customer driven consumer goods company with sustainability conscious buyers and retailers. The company is quite early in its sustainability journey and has a great support from its senior management and marketing departments. Lack of in-house resources such as DfS tools, clear definitions and skill sets on sustainability. Being part of a corporate group, the company receives clear guidelines directing it. Smaller size of the company and market presence in certain categories makes it challenging to integrate sustainability along the value chain. The company aspires to be a market leader in sustainable alternatives as its larger competitors.
Persona 3 (<i>Microbes</i>)	The company has a long tradition of providing sustainability solutions to customers and operate in B2B industry. Sustainability is strongly integrated to the senior management of the company and is involved in all PD stages. Stage gate models and DfS tools are used in a systematic manner in all projects. A lack of common understanding on sustainability is an identified challenge that leads to discussions. The company aims to integrate DfS focus in all management decisions and make it more visible in the nearest future.
Persona 4 (<i>Pouch</i>)	The company operates in a niche industry of vital and intimate support to customers, making utility, reliability and quality of its products the biggest priorities. Therefore, the customers do not have a high sustainability demand. The company however realises the impact of its activities and is committed to reducing the impact without comprising the utility of the product, this has been often challenging. A lack of common awareness among the different departments on DfS has been a big challenge in the company. Sustainability assessments are not regularised even though the company has the necessary skill sets. The company aims at consistent sustainability improvements in its products.

LENS/PERSPECTIVE	
STRUCTURAL / ARCHITECT'S	Sources
Design ecodesign guidelines and develop/internalize decision-support tools	L,I
Integrate ecodesign procedures in processes related to product development	L,I
Set ecodesign targets at different levels (e.g. corporate, products, innovation projects)	L,I
Include ecodesign in design criteria	L
Assign responsibilities for ecodesign (e.g. added in job descriptions of product designers) at different organizational levels	L
Integrate ecodesign into the business mission/strategy	L
Integrate ecodesign criteria in performance measurement systems (e.g. KPIs, internal labeling)	L,I
Design ecodesign strategies	L,I
Create dedicated organizational units and jobs for ecodesign visible in the organigram	L,I
Establish system for ecodesign information collection	L
Implement environmental management system/standards	L
Integrate ecodesign aspects in the fuzzy front end/early stages of development	L
Translate corporate strategy into action plan for specific business units/functions, Translate corporate targets into targets for individual innovation projects	L,I
Compose project teams with all relevant functions to address ecodesign (e.g. environmental specialists)	L
Design ecodesign policies	L
Establish ecodesign expertise/knowledge sharing process and platform (e.g. for lessons learned, successes, avenues for future investigation)	L
Integrate ecodesign in portfolio management	L
Set project processes allowing for development of radical innovation	L,I
Define scope of ecodesign, make it measurable, tangible	L,I
Acquire in-house expertise on ecodesign	L
HUMAN / CATALYST'S	Sources
Provide tailored training for employees (e.g. in their context, adapted to their daily tasks)	L
Use co-creation/participative approach (e.g. to include criteria in project tool)	L,I
Provide empowering tools (e.g. adapted to the nature of jobs and skills)	L
Support/chaperon teams with environmental experts/expertise	L,I
Address differences between individual sensitivities/needs/emotions	L
Give room for experimentation, autonomy	L,I
Involve and support people who have personal aspirations for ecodesign, target people "who burn for it"	L,I
Provide appreciation and support	L
Raise awareness or motivation with employee newsletters, podcasts, site events, trips	L
Translate ecodesign concepts in easy to understand terms, easy-to-understand/familiar terms/problematics	L, I
Use success stories to raise motivation	L
Understand what motivate employees or leads them to resistance (e.g. through workshops)	L
Collaboration with Human Resources department	L

Table A.2: List of four lens measures based on data collected in interviews and literature review detailed in Stewart et al. (2018); L = from literature, I = from interviews, KPI = Key Performance Indicator

Explain/inform employees about ecodesign (e.g. “why”, “how”, “when”, “who”)	L
Give responsibility and support for initiative taken	L
Make it easy to find information about ecodesign	L
One-to-one encounters	L
Reassure employees (e.g. about workload)	L, I
Stimulate and support individual employees to share ideas	L
Use nudging techniques, i.e. leading without inducing guilt or being prescriptive	L
Increase comfort of people to work with the topic of ecodesign	I
Build individual awareness of impact of decisions	I
Trigger people/”plant seeds”	I
POLITICAL / ADVOCATE'S	Sources
Have top management explicitly express ecodesign as a priority/commit for ecodesign (e.g. involvement in decision-making, public statements, responsibility for ecodesign goals)	L
Allocate resources/budget	L
Foster the development of ambassador(s) for ecodesign in the organization	L,I
Use success stories to create buy-in	L
Build awareness among key decision-makers	L
Communicate risk and benefits to the organization, emphasize criticality/emergency for business	L,I
Demonstrate value of ecodesign for different functions and the company	L
Influence and find/ally with employees who will be able to influence others	L,I
Understand resource availability and target low-hanging fruit	L,I
Allow ecodesign champions to network in the organization	L
Align and adapt ecodesign communication to different departments (e.g. different language/terminology)	L,I
Enable access to resources for ecodesign initiatives	L
Identify and leverage existing competencies in the company	L
Manage the gap between expectations and capabilities	L
Seek for interactions compatible with each group's priorities and agendas	L
Negotiate prioritization of ecodesign KPIs in agendas	I
Secure present resource allocation for long term/more prospective objectives	I
Leverage existing umbrella projects in the organization (i.e. leverage their visibility, resources, priority level)	I
Show solid knowledge of technical matters (expertise as a way to influence)	I
CULTURAL / PROPHET'S	Sources
Celebrate ecodesign successes and heroes (e.g. awards)	L
Adapt tools to the company's way of working	L
Efforts of environmental teams to be accepted as core members of the product development community	L
Use or creation of rituals (e.g. create regular events around products)	L
Storytelling about the founder's choice, communicating how it fits with the way of working	L
Value testing and failures	L
Develop common heuristic rules	L
Change perceived mission of the company, make sustainability part of the DNA, what people believe they are working for	L,I

Table A.2 *Continued*

Identify and break the poor history of ecodesign at the company	L
Negotiate/translate meanings with product development teams	L
Provide inspiration on ecodesign to the organization	L,I
Preach in the company (e.g. by recurrently bringing up ecodesign topic in presentation, introductory speech of development projects)	I
Generate new truths/meanings around products	I
Change false common beliefs/misconceptions (e.g. that environmental teams can affect product environmental performance by the conduction of environmental assessments)	I
Leverage “typical ways of doing”/routines/habits in the organization (e.g. ways of communicating)	I

Table A.2 *Continued*

Part II

Research Papers

PAPER I. PROJECT MANAGEMENT

- Authors:** Faheem Ali, Casper Boks, Niki Bey
- Full Title:** Design for Sustainability and Project Management Literature - A review
- Published in:** *Procedia CIRP* 2016
- Purpose:** To explore the relevance of Project Management literature in DfS implementation scenario and to identify the potential learning points from PM to DfS and PM has featured in the extant literature on DfS.
- Method:** Literature review covering articles on on DfS implementation challenges, best practices in Project Management relevant for DfS implementation and earlier studies where PM and DfS have been studied in each other's context. Scopus and ISI Web of Science were the databases used to identify 32 articles.
- Results:** Despite the relevance on a managerial approach to DfS implementation involving a multitude of actors, very few studies have actually mentioned the need for studying PM in DfS context. Further, PM studies in other environmental topics were also found to be lacking. Nevertheless, a few interesting coupling points on human resource management and multistakeholder communication were identified from PM literature that can potentially improve DfS implementation in companies.
- Contributions:** Discussion on PM literature from different application environments was studied to identify steps and frameworks that can be applied to mitigate organisational challenges affecting DfS implementation based on the context of a company.

23rd CIRP Conference on Life Cycle Engineering

Design for sustainability and project management literature – a review

Faheem Ali^{*a,b}, Casper Boks^a, Niki Bey^b

^aNorwegian University of Science and Technology (NTNU), Department of Product Design, 7491 Trondheim, Norway

^bTechnical University of Denmark (DTU), Department of Management Engineering, Division of Quantitative Sustainability Assessment, Produktionstorvet, Building 424, 2800 Kgs. Lyngby, Denmark

* Corresponding author. Tel.: +47 735 90 128; E-mail address: Faheem.ali@ntnu.no

Abstract

The growing pressure on natural resources and increasing global trade have made sustainability issues a prime area of concern for all businesses alike. The increased focus on sustainability has impacted the way projects are conceived, planned, executed and evaluated in industries. Since project management literature has hardly been considered in design for sustainability research, this article attempts to review the points of intersection between these two fields, and explores the potential that knowledge from project management literature has in improving efficiency and effectiveness of development and implementation of design for sustainability tools.

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Peer-review under responsibility of the scientific committee of the 23rd CIRP Conference on Life Cycle Engineering

Keywords: Design for sustainability; project management; product development; ecodesign

1. Introduction

The last few decades have witnessed increasing interest and attention for sustainability issues, and companies and industry branches around the globe increasingly see this as an opportunity to seize the potential business behind sustainability initiatives. Searching for ways to introduce and implement design for sustainability within industry has been one of the primary responses from the academia; and this has been mainly done in the form of method and tool development. However, research on the industrial state-of-the-art, both older [1]–[3] and more recent [4], [5], suggests that the application of these tools is marred by low degrees of implementation of design for sustainability (DfS) tools in “real life” industry [6].

An evident change brought about by the focus on sustainability is the change from product based systems to the product-service based systems [7]. Further, earlier works by Johansson [8] and van Hemel and Cramer [9] also highlight the need for internal stimuli in the form of innovation possibility, competence building within the company, customer relationship, management commitment etc. as some of the major success factors for successful integration of DfS in

industry. More recently, Brones et al. [10] observe that these changes, among others, have necessitated research to explore the need for an overview of the various activities associated with DfS in the industry. Further, the need to have a holistic approach by considering various elements of design of sustainability as part of a single system has also been argued for in the environment friendly design context [11], [12]. The need to factor for increasing organisational complexities and importance of communication at different stages of eco-design product development [13], [14] also highlight the need for a project based approach to the topic of DfS. For the purpose of this research work, DfS is defined as the product design and development process with careful consideration of relevant aspects that can mitigate many environmental, societal and economic challenges during the life cycle of the product [15].

Stressing upon the need for project management in the sustainable development context, Labuschagne and Brent [16] observe that project management, being the “core business methodology” of most companies, cannot be excluded from the discussion on sustainability. It is in this context that this article explores the applicability and presence of project management focus in the existing DfS literature. Literature on project

management practices and knowledge has been diverse and vivid. Among these academic works, the Project Management Body of Knowledge (PMBoK) issued by the Project Management Institute (PMI) has been widely used as the basis for various terminologies and guidelines in industries. Subsequently, this research work also uses PMBoK as a reference for the analysis on project management practices and terminologies. For the purpose of research and analysis, the following definition of project management from the PMBoK (4th Edition) is used:

“Project management is the application of knowledge, skill, tools and techniques to project activities to meet the project requirements”.

Based on these constructs the following sections explore and present findings from literature on to what extent project management has been discussed in DfS literature and how it can help addressing the commonly faced challenges in DfS implementation.

2. Research Method

As the topics of DfS and project management are quite diverse, the study explores both topics in a two stage literature review method, as illustrated in Figure 1.

The two stage analysis was opted for, as it helped in providing a streamlined overview of the state-of-the-art of both project management (PM) and design for sustainability (DfS) in relation to each other. The second stage analyses these findings to explore the insights and possibilities that can arise when PM is studied and applied to the DfS implementation

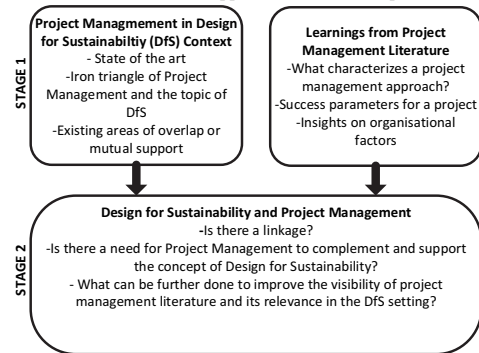


Figure 1 The two stage research model adopted for this paper

process.

The findings from these two stages were then analysed in parallel to drive the discussions presented in the later sections of this article. A literature review on the topic intends to provide a comprehensive understanding of the existing academic research in the area [17], [18].

For streamlining the literature review process, two major databases were selected, namely, ISI Web of Science and Scopus. These selections were made mainly due to two reasons, the detailed meta-data available from these databases that facilitated supplementary research (1) and the relevance of

design for sustainability literature in these databases (2). Literature review was carried out based on a wide ranging choice of terms and areas, such as ‘project management’, ‘change management’ ‘project control’, ‘design for sustainability’, ‘eco-design’, ‘method’, ‘tool’ etc. Section 3 presents the findings from the literature review, followed by discussion on the findings in section 4.

3. Results of the literature review

3.1. Stage 1: Design for sustainability and project management in each other’s context

While there is abundant literature on both DfS and PM separately, there appears to be little research that builds on insights from both fields simultaneously. The exploratory research on articles dealing with both topics returned only 52 articles in ISI Web of Science, while Scopus search gave a list of 67 articles. On further applying filters and eliminating the

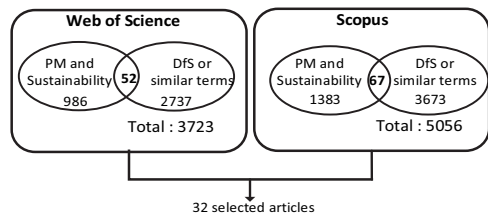


Figure 2 Literature search results in selected databases

same articles in both the databases, the list was shortened to 32.

The first part of stage 1 analysis looks into the project management literature to identify and highlight features from project management processes, organizational parameters and success factors that can augment and refine the DfS context. Project management literature is vast and addresses a multitude of issues pertaining to projects within organisations. However, as mentioned above, this section of analysis restricts itself to areas in project management literature that the authors believe are relevant in the DfS implementation context. For example, project management research on project success factors, impact of organisational diversities on project execution and managing these diversities, different processes in implementation stages of projects etc.

A wide range of project management literature identifies the three basic success factors for any project, namely, cost, time and quality [19], [20]. Known as the iron triangle, it evaluates how successful the project has been in achieving the stated quality within the budgeted cost and estimated time. But to arrive at this evaluation stage, a project passes through different processes. The Project Management Body of Knowledge (PMBoK) identifies five different processes that needs to be carried out simultaneously for swift information flow between various stakeholders of the project and to meet the overall project requirements. They are:

1. Initiating process group: The process group that define a new project or a new phase of the existing project by obtaining necessary authorization.

2. Planning process group: These process groups define the scope of the project, refine the objectives and decide the course of action for achieving these objectives.
3. Executing process group: This process group include the activities performed to achieve the goals stated in the project plan.
4. Monitoring and controlling process group: Those groups that monitor, regulate and review the project activity.
5. Closing process group: The final process group entails steps taken to close all the activities associated with all process groups to formally end the project or phase [20].

These processes streamline the transition from conception of the product/project to the final delivery and feedback loop involved in it. These do not occur in isolation and thus interact with each other. Especially, the penultimate process group of “monitoring and controlling process” stresses upon the need for knowledge transfer between the organizational stakeholders and different departments in order to facilitate similar projects in the future.

Learning from completed projects is a vital element even in the DfS context. Boks and Stevels [21] mention this as one of the main reasons why an environmental benchmarking tool was developed by Philips, as most environmental design issues were often addressed in isolation from the day to day to business. Schindler and Eppler [22] identifies a series of success factors to gain lessons learned from the debriefing phase of projects. The list includes continuous and regular capture of important project experiences, presence of an external/ neutral moderator for the final debriefing session, a collective and interactive evaluation and analysis of experiences from individual members, among others.

Further, successful transfer of knowledge is not possible as long as the cultural and soft side context of the receiver is not taken into consideration. Boks [13] highlights the importance of ‘soft side’ parameters in the eco-design context, which include factors such as social and psychological aspects of individuals, lack of commitment and unwillingness to cooperate among other organizational complexities. The literature review on project management literature also identified certain discussions on the role of human-related organizational parameters in successfully realising project goals. For example, in its definition of project management, the Project Management Institute (PMI) identifies human resource management as one of the six fundamental functions of project management [20]. Belout and Gauvreau [23] observe that project personnel have a considerable effect on the success of the projects and hence need to be taken into consideration while deciding upon the staffing process in projects. The PMBoK draws out a 4 stage process for human resource management in projects. These processes range from defining the project scope for each individual involved to the competence required to develop and manage the project team.

A crucial factor in successfully controlling the soft side of project teams is to educate and create a consensus among the

people involved on the expected outcomes of the project and the ways to achieve it. A few of the tools and techniques identified for this purpose are as follows [20]:

- Organisation chart and position description
- Networking and team building activities
- Co-location of employees involved
- Recognition and awards for performances
- Continuous and regular conflict management
- Project performance appraisals
- Observation and conversation
- Issue logs

Thus, the project management literature has a great potential in contributing to the expanding field of DfS from both theoretical and practical perspectives. These insights on the systematic approaches in PM literature and their possible contributions to DfS is discussed in the following sections.

The second part of stage 1 analysis reviews how scientific research on project management has been featured in a DfS context. Though articles exclusively on this are very few, a general observation in these shortlisted articles is that emphasis on the triple success factor of project management, i.e time, cost and quality are rarely addressed from a DfS perspective. So is the case with execution phase of eco-design projects. As observed from similar case studies by Brones et al. [10] and Wu and Pheng Low [24], literature on DfS focuses mainly on the technical issues, models and frameworks and little on issues related to managing the process itself.

However, Santolaria et al. [25] observe that in reality, DfS calls for continuous improvement and innovation rather than incremental changes to products to remain valid and to deliver the desired results. The product innovation process, as discussed in the literature, rather reflects a chaotic circular model instead of the conventional linear model of product development [26]. Buijs [26] argues that product innovation can be visualized as a continuous process with neither a fixed ending nor beginning, thus validating the importance of project management in DfS.

Further, case studies carried out on the integration of DfS to the product development process (PDP) in various industries, suggest that the concept of integrated thinking between various stakeholders and parameters in the DfS field is important for real transformation of design practices [27]–[29]. Tingström et al. [30] demonstrate how the integration of the sustainability thinking in project management practices enabled ABB, a large Swedish company in energy and automation, in successfully improving the environmental performance of their products. A general trend in the DfS literature has been the numerous tools, methods and frameworks aimed at facilitating the application of both technical and managerial practices associated with DfS. Pigosso et al. [31] identify 126 different tools in the literature. However, most of these tools are seldom used in a systematic manner by companies, thus failing to deliver the desired results [1]. This provides a rationale for investigating on upto what extent project management elements have been embedded in these tools. This can act as a precursor for understanding how project management elements can be integrated with some degree of feasibility.

A good number of reviews and analyses on eco-design tools have been presented by the academia [27], [32]–[35]. Most of the reviews have analysed the usability, functionality and depth of results these tools present. A general observation from these reviews is that project management elements or processes are either entirely missing or lack focus in these tools. This may primarily be the case because the targeted users of these tools have been mostly designers, without focus on others involved in the product development process and the management thereof.

Most of these tools were made for standalone purposes and thus are void of elements intended to include these tools in the daily business processes. Eco-design tools such as PILOT by Wimmer et al. [36], Environmental benchmarking an internal tool by Philips, EIME (Environmental Information and Management Explorer) provided by CODDE are some that were meant to be integrated in daily businesses. The environmental benchmarking, for example, was developed in order to overcome the shortcomings in resolving environmental issues related to design as isolated projects. The main weakness being the lack of follow up of executed projects and transfer of knowledge acquired from it [21]. Though some elements of project management literature can be found in these eco-design tools, they lack the depth on project execution processes and focus on organizational factors explained earlier in this stage. A few other widely discussed tools such as the MET Matrix, Ten Golden rules and LiDS wheels are mostly checklists or guidelines aimed at highlighting the important factors that designers need to consider when addressing eco-design issues [34], [37]. This excludes the execution phase of such eco-design initiative from its scope. Thus, it is judicious to conclude that research on DfS has to a great extent excluded the importance of project management in sustainability implementation processes.

3.2. Stage 2 : Design for sustainability and project management – Interlinkage, need and possibility

The second stage of analysis covered the need for interlinkage between DfS and PM. The aim of this stage was to identify the likely possibilities that literature on PM has to offer in order to overcome the various challenges and barriers faced by the DfS concept. Though it is difficult to analyse and present a comprehensive list of barriers and challenges in the DfS context, the following section summarizes some of the major challenges that can be addressed by learnings from the PM literature.

One of the most discussed barriers to successful implementation of DfS is the lack of proper communication flow between various stakeholders involved in the process. Boks [13] opines that the most important obstacles found in the literature are about two-way communication and cooperation, and not the success factors enumerated during the top-down process of determining success of DfS implementation. The methods for more effective communication and stakeholder integration is a deeply studied topic in the project management literature. In their article on greening project management practices Robichaud and Anantatmula [38] observe that the charrettes have great potential in facilitating dialogue among

the stakeholders and also in highlighting the interest of all the concerned partners right from the beginning of a sustainability focussed project.

Waage [39] argues that another main challenge with DfS is the difficulty in material coordination and right material selection. The difficulties are mainly two-fold, firstly due to the inadequate, inappropriate or unverified information on the environmental performance of many materials [34], [40], [41]. Secondly, most sustainability initiatives according to Waage [39] are devoid of the larger picture where the impact accumulates due to multiple units of the same product. Academic research on project management scenarios involving various interest groups and impact areas elucidate a number of methods and frameworks to map and analyse the impact of a project activity on various stakeholders. Based on a survey carried out among various project managers in Norway, Karlsen [42] proposes six steps that would help in identifying and understanding different impacts from the project at different stages of execution. Olander [43] and El-Gohary et al. [44] also elucidate similar case study examples on coordination in the project management milieu.

Cultural diversity existing within and among organisations and firms has been often identified as a challenge in realizing the goals set during sustainability implementation [13], [45]. In an exploratory study covering people from 53 geographic areas, Hofstede [46] explains how different national cultures impact project management and how cross-cultural sensitivity helps in exploring the benefits of diversity. Further, researchers have studied how an understanding of national cultures (identified by Hofstede and further) impacted various project management scenarios [47], [48]. Findings from such studies can contribute to the ongoing discourse on the role of cultural diversity in sustainability implementation.

In a review on various dimensions of the concept of eco-design, Karlsson and Luttrupp [49] observe that the primary aim of eco-design initiatives needs to be eco-effective products rather than eco-efficient ones. Karlsson and Luttrupp also opine that market priorities, lifestyle preferences and immaterial aspects of the product being designed are fundamental challenges that need to be addressed [49]. Exploring a similar dilemma in project portfolio selection, Archer and Ghasemzadeh [50] proposes a framework which involves multiple stages directed towards streamlining various parameters that determine project portfolios. This multi-stage framework stresses upon factors that are not entirely product related, but also relate to market forces, individual preferences based on resource availability etc. A few other researchers also discuss similar frameworks and methods on project portfolio selections that can address similar challenges in sustainability implementation [51]–[53]. Further, the project management processes identified in stage 1 of this article also put forward a number of methods to overcome these organisational challenges identified in DfS in a systematic and project based manner.

In a distinct take on the potential of change management in the DfS discussion, Verhulst et al. [54] point out the potential of using the change management concept in eco-design product development as an aid to overcome many human related barriers. Verhulst et al. [54] also present four propositions

connecting the obstacles faced in eco-design literature and constructs in change management literature. Firstly, the gap experienced between the proponents and executors of sustainability strategies can be addressed by theory on organisational resistance. The second proposition is on how effective communication strategies can mitigate lack of cooperation among different individuals and departments in a firm. The third proposition explores how the lack of commitment among individuals in sustainability implementation can be addressed by steps based on theory of organisational resistance. The final proposition deals with cultural differences and states that these differences can be explained by understanding the varying perspectives at the organisational level.

This section presented some of the widely experienced challenges in DfS implementation and how insights from project management literature enable in tackling these challenges.

4. Limitations and discussion

The results from the literature review show that project management has seldom been focused upon in the DfS discourse. On the contrary, the project management literature reviewed present insightful views on addressing various issues commonly faced in DfS implementation. The PM process groups mentioned in the article is an example on how to approach any eco-design project in a systematic manner. Stakeholder management has been another pertaining issue in sustainability implementation. Project management literature presented in this paper also discusses on how various stakeholders involved in a project can be used effectively to deliver the desired goals.

Another major point of intersection between DfS and PM is the methods and needs for addressing human or organizational related factors in eco-design projects. A sample list of tools and techniques prescribed in the project management literature has been presented in the article. The authors believe that as DfS becomes more project based, soft side parameters as highlighted by Boks [13]; and Verhulst et al. [45] have an increasing importance in industrial implementation of DfS. Thereby, a knowledge of these PM tools will aid the discussions on soft side parameters in DfS implementation.

The discussion presented on the barriers faced by DfS and solutions from project management literature reveals the complimentary nature of DfS and PM. This is all the more important as several researchers support the view that barriers to DfS implementation are mostly individualistic and company specific [45], [55], which is also the case with project management practices. These observations indeed present an interesting field of research for further study on intersection between PM and DfS.

A limitation in this exploratory study could be the research methodology used. This methodology was adopted mainly due to the broad nature of the topics that were discussed. As mentioned earlier, academic work addressing both PM and DfS together is scarce and narrowing down the scope of the article

was a challenge that the authors faced in the initial stages of analysis. However, the authors are of the view that an in-depth reading of both project management and DfS literature in tandem will greatly enrich and enhance the ongoing research on sustainability implementation.

5. Conclusion and future work

Based on existing literature, this article carried out an exploratory literature review on the role and presence of project management literature in the DfS context. The study was carried out in a two stage process, in which stage I examined the state of the art linkage between project management and DfS, and stage two analysed the need and possibilities arising from an interlinkage between the two.

The major scientific contribution by this article has been two-fold. Firstly, as argued upon in the earlier sections of this article, the study reveals a clear missing linkage between PM and DfS. Secondly, focus on PM holds great potential for the field of DfS, especially from the latter's focus on organizational parameters and human side factors in realizing successful projects. Thus, these highlight the possible interconnections between two topics that have been, to a large extent, studied by the academia in singularity. The article thereby sets a stage for further study and discussion in the academic circles on the importance of incorporating project management approach in DfS research.

Future work on the topic can include extensive field studies to identify, analyse and develop a structured overview of overlap between PM and DfS. From an academic perspective, it could be of particular interest to document how project management helps in tackling various implementation barriers faced by companies involved in DfS initiatives.

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PAPER II. NORDIC APPROACH

- Authors:** Faheem Ali, Elli Verhulst, Casper Boks
- Full Title:** The ‘Nordic Approach’ and how it may support Design for Sustainability
- Published in:** Proceedings of NordDesign Conference 2016
- Purpose:** To explore if there is something called ‘Nordic Approach’ that influence the implementation of sustainability in companies based in Scandinavia. If so, identify the characteristics of such a ‘Nordic Approach’ and what role it can likely play in DfS implementation scenarios in companies.
- Method:** Literature review covering extant literature discussing the ‘Nordic Approach’ in organisations and its influence on the organisation’s functions. This was coupled with DfS implementation challenges identified from a complementary literature review. Scopus database was the primary source of articles.
- Results:** The presence of a ‘Nordic Approach’ that distinguishes Scandinavian companies from others was identified and its characteristics discussed. Possible coupling points between these characteristics and DfS challenges are presented and discussed.
- Contributions:** The different contextual factors of Scandinavian companies that are likely to facilitate DfS implementation were identified. Even though these characteristics are seemingly conducive to DfS implementation in these countries, this is not always the case. A discussion surrounding this is presented and calls for further research by academia on this topic.

The ‘Nordic Approach’ and how it may support Design for Sustainability

Faheem Ali, Elli Verhulst, Casper Boks

*Department of Product Design, Norwegian University of Science and Technology,
faheem.ali@ntnu.no, elli.verhulst@ntnu.no, casper.boks@ntnu.no*

Abstract

The Nordic industries have been considered to be one of the first movers on sustainability related topics. This research work aims at exploring the ‘Nordic Approach’ in a Design for Sustainability (DfS) context and is based on findings from existing literature and industrial reports in a broader field of research pertaining to the Nordics. The paper investigates and presents factors and drivers that distinguish the Nordic countries from the rest of the world. This work concludes with a discussion on how a thorough understanding of what the Nordic Approach entails may improve further theoretical and applied work related to Design for Sustainability. Such an understanding may in turn inform a discussion on the potential need for customised tools, methods and approaches for implementing Design for Sustainability within Nordic industry and public work environments. The paper also identifies future research potential correlating the ‘Nordic approach’ and DfS.

Keywords: *Design for sustainability, Nordic Approach, Soft side, organisational factors, change management*

1 Introduction

Sustainability encompassing the triple bottom line of economic, environmental and socio-ethical aspects has become an indispensable part of industrial activities around the globe. Increasing attention from policy makers, governments, academics and companies have made sustainable innovations a pivotal part of business strategies. Moreover, including environmental and social aspects in business development has increasingly proven to provide a competitive advantage for companies over their competitors (Porter & Kramer, 2011). Product design and development has an important role in this process because, careful consideration of relevant aspects can mitigate many environmental, societal and economic challenges during the life cycle of the product (Brezet & Van Hemel, 1997). There has been a shift of focus in Design for Sustainability (DfS) research from mainly technical, product related approach to more organisational, managerial and business related areas and its impact on the subject of DfS (Boks, 2006; Boks & McAloone, 2009; Daae & Boks, 2015; Tukker et al., 2001; Verhulst, Boks, Stranger, & Masson, 2007). Subsequently, one of the areas of research on DfS focuses on its implementation in companies and emphasises the need to

include a larger arena of influential factors. This latter direction in research has predominantly focussed on topics such as organisational behaviour, human related factors, organisational characteristics, cultural and language diversity and their impact on DfS implementation. The increased internationalisation and complex interdependencies between markets emphasize an even larger significance of these factors in discussions on DfS. Hofstede, (1983) observes that nationality is a crucial part of management for three reasons. Firstly, nations are politically rooted historical units with mutually differing formal institutions that are hard to converge. Secondly, the sociological factor of common identity among people from a nation or region distinguishes them from the rest. Thirdly, the psychological factor, that our thinking is partly influenced by our culture, family and childhood experiences, which differ from country to country. These observations make it an interesting academic proposition to explore those factors that are unique to a region or country, and that could possibly have an impact on the successful implementation of DfS strategies.

Scandinavian industries have been first movers in various sustainability initiatives and are also home to many companies that perform well in sustainability indices around the globe. This includes the Dow-Jones Sustainability Index (DJSI) and the Global 100 Index. The 'Nordic' countries which include Norway, Sweden, Denmark, Finland and Iceland have been widely discussed in sustainability and organisational management context in both industrial reports and academic literature (Emmelin, 1998; Lindell & Arvonen, 1996; Lindell & Karagozoglu, 2001; Smith, Andersen, Ekelund, Graverson, & Ropo, 2003). Further, the term approach is defined as *'to make advances to, especially in order to create a desired result'* (Webster, 2006). The usage 'Nordic approach' in this research work thus entails the Nordic method of carrying out tasks and style of functioning in the organisation. Furthermore, the socio-cultural similarity existing among the Scandinavian countries makes it a good choice to be analysed as a single unit (Poulsen, 1988). This research work aims at reviewing existing evidence in literature for a 'Nordic approach' that distinguishes business activities within Nordic companies and industries from the rest of the world. The research also explores how an understanding of such an approach, if it exists, can help ongoing academic research and discussions on sustainability implementation in industries. Subsequently, the 'Nordic approach' observed in a broader set of literature is considered as the unit of analysis for this paper.

2 Research Methodology

As mentioned earlier, the research work for this paper has been based on literature review of existing work in academia and industry that deal with the topic. A literature review on the topic intends to provide a comprehensive understanding of the existing academic research in the area (Denscombe, 2014). The larger research project, of which this paper is a part of, intends to use the results presented in this paper as a point of departure for a detailed case study on DfS implementation in industries from a Scandinavian perspective. Thus, the findings and discussions presented in this paper would contribute to the triangulation process in the case studies that will follow in the larger project outline (Bryman, 2012; Yin, 2009).

A comprehensive search string covering various dimensions of the topic of study was developed to streamline the literature search and to include research and findings from relevant sources. Scopus was selected as the main scientific database mainly because of two reasons, firstly, the detailed meta-data available from this database facilitated supplementary research and secondly, the depth of relevant literature in this database. The search strings used in the literature review process were related to 1) literature on the geographic area of

Scandinavia, 2) academic work on institutional entities, and 3) different organisational parameters that can be observed in such institutional entities. Further, in order to identify the insights from existing academic research covering Scandinavia and the topic of sustainability, an additional list of independent variables were also used in the literature search process.

Subsequently, as illustrated in Figure 1, a three stage research method was devised to investigate the factors outlined in Section 1. Stage 1 of the research work involved finding factors that characterised the Nordic style of functioning in different academic segments. Further, it also studies how the Nordic style is different from other identified academic works on regional and organisational culture (Section 3.1). In stage 2 some of the commonly identified human-side challenges in DfS implementation are presented (Section 3.2). Together this provides food for discussion on how insights on the Nordic style may benefit DFS implementation. This is briefly touched upon in Section 4, thus indicated by dotted lines (Stage 3).

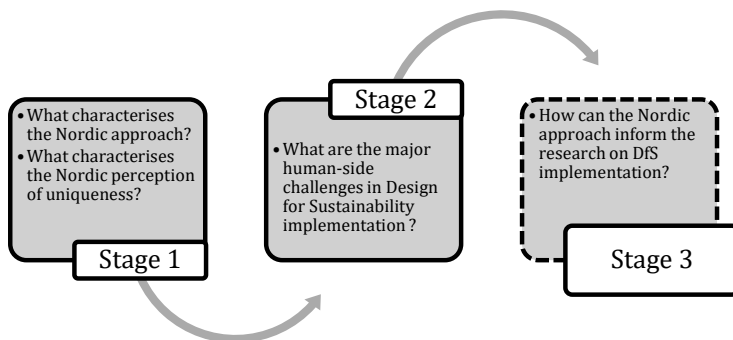


Figure 1 The research approach - an illustration

3 Results from the literature review

This chapter presents the findings on ‘Nordic approach’ and on DfS implementation that was identified in the literature review process. A total of 37 articles were identified and selected for analysis. These articles were selected based upon their focus on the Nordic organisational culture and comparative discussions on other regional cultures. Since the main focus of this article is on understanding the Nordic approach, only 9 of the selected articles discuss the DfS literature and implementation challenges.

Smith et al., (2003) observe that research on the Nordic management style has been mostly characterised by researchers from two different backgrounds. The first kind of researchers who are from outside the Nordic geographic region approached the Nordic management style and its way of functioning as part of an attempt to highlight existing global variations in the field. Hofstede (1980) and House et al. (2004) are some examples. In contrast, researchers from within the Nordic region have put larger focus on bringing out attributes considered unique to that region (e.g.: Hall et al. (2009); Hvid et al. (2011)) . The latter academic work has thereby helped in highlighting the Nordic uniqueness in terms of culture and organisational characteristics. Both these findings are further discussed in the following section.

3.1 Stage 1: The Nordic socio-cultural dimension

In his classic survey covering employees of a multinational company with presence in 40 different countries, Hofstede (1980) states that culture is characterised by four major dimensions;

- Power distance (unequal versus equal)
- Uncertainty avoidance
- Individualism/Collectivism (alone versus together); and
- Masculinity/Femininity (tough versus tender)

Among these four, Hofstede observes that the Nordic countries along with the Netherlands have very low power distance among the employees in the organisation. The Nordic countries were also found to be more individualistic in their approach, with initiatives driven by subordinates.

Hofstede further characterises the Nordic countries as having a more feminine culture, femininity according to him relates to the similar gender roles existing among both male and female (Smith et al., 2003). This mainly stems from the gender equality (termed as 'likestilling' in Norwegian) approach for which the Scandinavian countries are known for. This also follows the findings of Hofstede (1998), where the author identifies the feminine culture existing in the Nordic countries as a main reason for these countries having a larger female presence in leadership roles in the society and better work and family life balance.

However, Hofstede's dimensions address culture on a very general, national culture level and do not incorporate other societal or personal characteristics that may be typical for a certain geographic location and/or state of welfare. Proposing an agenda for organisational change in the work and family interface setting, Lewis & Cooper (1995) highlight the individual, organisational, family and community costs entailing an improper work and social life balance. These costs include personal work related stress, low efficiency in work, absenteeism and reduced quality of life. The Nordic countries have come out well in studies on the quality of life and work life balance. In a study comparing five different European countries in terms of work-life balance, Crompton & Lyonette (2006) observe that Norway and Finland score better than Portugal, France and the United Kingdom. Researchers opine that the long standing public policy initiatives since the 1970s in Scandinavia played a big role in achieving this balance between employee and family life (Gallie, 2003; Lewis & Cooper, 1995). These observations in literature lead to the concrete conclusions on how Nordic traditions and long standing cultural norms have served as a determinative factor in shaping organisational characteristics in the Nordics. The following subsections investigate some of these organisational characteristics in detail.

3.1.1 Flat organisational structure in Nordics – its manifestations

The Nordic countries are known for their relatively flat organisational structure, which distinguishes its style of functioning. In a cross-cultural study between the market orientation of Nordic and US based firms, Selnes et al. (1996) observe that national context of the firms play a decisive role in its response to the market changes. The studies showed that interdepartmental conflicts were found to be low in Scandinavian firms and interdepartmental connectedness was on a higher level.

Empirical studies show that shared leadership in firms improve the team performance when supported with proper team autonomy in functioning, control and discretion over tasks and conditions (Fausing, Jeppesen, Jønsson, Lewandowski, & Bligh, 2013). The flat working

structure in the Nordic organisations in turn results in increased autonomy and low power distance within the management levels (Hofstede, 1980; Kasvio, Gonäs, & Skorstad, 2012). In a cross cutting review of organisational studies on the Nordic work culture, Hasle & Sørensen (2013) establishes that employees in the Nordics are autonomous beings possessing individual and collective aspirations that drive their commitment and increase their individual contribution to the firm's activities.

3.1.2 High degree of stakeholder approach

Another feature identified in the Nordic style of organisational working is the increased stakeholder involvement in the functioning of the organisations (Lindell & Arvonen, 1996). Kasvio et al. (2012) mention a Norwegian example of how high degree of stakeholder involvement benefits all concerned parties in an organisational setting. This also follows de Monthoux's (1991) view on a participatory style of working in Swedish companies, where people are taken seriously only when they speak on as part of the collective group appreciating different views in the group. Another study on national culture and hierarchy also concludes that this participatory style of organisational functioning is found to be ingrained in Nordic organisations. This leads to an improved cohesiveness among different organisational units within the firm leading to improved conflict resolution and lesser uncertainty in activities (Laurent, 1983).

3.1.3 Task orientation

In a comparative case study on the Nordic management style in an European context, Lindell & Arvonen (1996) observe that Nordic managers stress upon the need for proper planning and order in the activities of the company and communicate the details more with their subordinates. The Nordic organisations are thus less task oriented, giving more freedom to the employees to achieve the targets based on the inputs they receive (Smith et al., 2003).

3.1.4 Employee orientation

In study mentioned earlier, Lindell & Arvonen (1996) also study the employee orientation in the Nordic firms, and find that Nordic managers allowed employees to make decisions and showed regard for the individual they were. The article observe that it was based on the mutual trust and consideration that the employee and manager had for each other.

3.1.5 Innovation driven

Exploring the influence of management control in empowering the employees, Simons (1995) argue that effective managers empower their employees, giving them enough room to innovate and add value in their activities. The Nordic managers are known to encourage their employees to think along new lines and are open to discuss new ideas (Lindell & Arvonen, 1996; Smith et al., 2003).

3.2 Stage 2: Design for Sustainability implementation – human-side challenges and needs

Since it is beyond the scope of this paper to identify all DfS challenges and literature, this section only presents a brief overview of some of the widely identified human related challenges in DfS implementation literature. However, some of the relevant literature is also cited in Table 2. For a better understanding of DfS, it is also worth mentioning that the topic of DfS can be further explored in works of Aschehoug S., Boks C., Baumann H., Verhulst E., Lindahl M. et al. The challenge of successful implementation of DfS has entailed a number of factors, not only technical aspects but also socio-psychological factors (Boks, 2006; Boks & McAloone, 2009; van Hemel & Cramer, 2002; Verhulst & Boks, 2012, 2014) . Among these,

one observation is that there is a need for effective and continuous communication between different stakeholders involved in the implementation process (Schindler & Eppler, 2003); it has been hypothesised that the latter may be of particular importance in the context of sustainability, as it still is a relatively new concept, intertwined throughout the whole internal and external value chain. Another hypothesis is that for example a flat, participative management style – typical of Nordic management approaches, may ensure a continuous chain of communication between various levels of the organisation.

Another observation from DfS literature is the need for empowerment of personnel involved in the implementation process. Based on a number of case studies, Verhulst & Boks (2014) identify three dimensions of empowerment, namely;

- **Authority:** involving power, decision-making and responsibility.
- **Resources and specialisation:** Information, knowledge and skills.
- **Self-determination:** creativity, autonomy and initiatives.

The terminology used in the above definition of empowerment is similar to some of the characteristics identified in the ‘Nordic approach’. The Nordic style of management provides individuals with sufficient autonomy and responsibility to contribute their ideas to the group. There is also strong emphasis on ensuring participation of all stakeholders in a decision making process, which in turn is said to promote creativity and encourage initiatives from the employees (Boks, 2006). Concomitantly, this approach also encourages a pro-active learning process among various involved partners.

4 Discussion

Based on existing academic literature, insights on what entails a ‘Nordic approach’ were explored and presented. As illustrated in Figure 2, the ‘Nordic approach’ is characterised by a number of features originating from the socio-cultural dimension of the region. It is our hypothesis that understanding and addressing these features may provide insights in understanding conditions for successful implementation of Design for Sustainability (DfS) in a Nordic context. As so far, literature on DfS implementation does not distinguish between different geographic reasons, this goes two ways:

- A better understanding can provide additional, geographic-specific insights on how DfS implementation in the Nordic business culture can be supported
- Should it become clear that the Nordic business culture is specifically supportive to DfS implementation, it provides food for thought on which elements of the Nordic approach may be implemented in other suitable geographic regions.

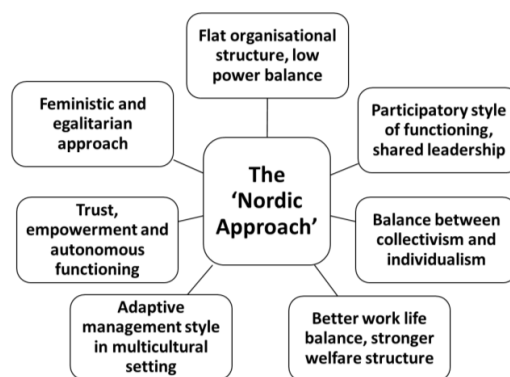


Figure 2 The 'Nordic Approach' - an illustration

4.1 Design for sustainability implementation – what the Nordic approach entails

Table 1 lists the ‘Nordic approach’ factors identified in this paper in conjunction with challenges and areas of difficulties identified in the Design for Sustainability implementation literature. In the third column in the table, we have attempted to identify how insights about the Nordic approach, when connected to known obstacles from DfS literature, may contribute to implementation thereof. So far, these remain hypotheses, and are put forward here to spark discussion and inspire for further research. For example, the high level of individuality and relatively flat structure of organisations may facilitate communication between individuals and departments, thus overcoming challenges related to communication, cooperation, and favouring bottom-up initiatives and creativity. Similarly, a tradition for stakeholder participation and mutual trust may contribute for more efficient innovation processes, faster decision making processes, and avoid distrust among different parties that are all needed to be ‘on board’ to push sustainable innovations forward.

Table 1 'Nordic approach' and Design for Sustainability - drawing parallels

Identified from ‘Nordic approach’ literature	Factors identified from DfS implementation literature that are relevant in the context	Possible coupling and potential benefit area
Flat structure of organisation (Selnes et al., 1996)	Need for effective communication (Boks, 2006)	Facilitates easy and open communication Supports (bottom-up) creativity in DfS product development process
Individualistic behaviour (Hofstede, 1980)	Need for creativity and self-driven individuals (Baumann, Boons, & Bragd, 2002)	Avoids uncertainty and conflict creation during DfS implementation
Lesser uncertainty (Laurent, 1983)	Need for cooperation (van Hemel & Cramer, 2002)	Ensures proper dissemination of information enhancing overall competitiveness of the firm.
Proper planning and order (Smith et al., 2003)	Need for proper dissemination of sustainability information (Aschehoug, Boks, & Støren, 2012)	Improved decision making process, avoiding inward focus
High degree of stakeholder approach (Lindell & Arvonen, 1996)	Need for complete stakeholder involvement (Tukker et al., 2001)	Easier translation of goals to action, increase acceptance
Strong employee orientation (Lindell & Arvonen, 1996)	Need for empowerment (Verhulst & Boks, 2014)	Exploiting creative approaches in DfS
Innovation driven (Smith et al., 2003)	Need for continuous improvement in eco-design environment (Santolaria, Oliver-Solà, Gasol, Morales-Pinzón, & Rieradevall, 2011)	Faster implementation process
Mutual trust (Poulsen, 1988)	Need to overcome scepticism associated with change (Knight & Jenkins, 2009)	Better adaptive results
Collective aspirations among employees (Hasle & Sørensen, 2013)	Aligning company goals with individual perceptions (Doppelt, 2003)	More (two-way) discussion, less rigid approaches
Feminine attitude (Hofstede, 1980)	Risk from patriarchal thinking and false sense of security (Doppelt, 2003)	Increase acceptance for work and responsibility changes in the firm
Egalitarian approach in society (Gallie, 2003)	Fear of work overload (Verhulst & Boks, 2012)	

4.2 Research potential and future work

The discussion presented in this paper highlights certain potential research areas that can contribute to more successful DfS implementation. Firstly, academic research on DfS implementation has been primarily driven by tool and method development, which has predominantly focussed on technical aspects of product development. Our review suggests that elements of the Nordic approach may support aspects such as internal communication, creativity, stakeholder dialogue and participation. The authors will continue to research how to incorporate the cultural and human side perspectives into tool, methodology and strategy development. Still, though the Nordic style of organising work environments seems relatively suitable for DfS implementation, ground reality still points towards room for improvement in companies in the region. Our review identified mostly aspects of the Nordic Approach that may support DfS implementation, but some aspects may pose challenges as well; an individual orientation and flat organisational structures may also be seen as obstacles in some contexts. A user based fact finding research on why Scandinavian companies fail in DfS implementation can enrich the ongoing academic discourse.

It is also a valid question to ask to what extent implementation in non-Nordic countries may benefit from our current insights, though answering this question is at this time not among our research priorities.

The future work based on the discussion presented in this paper shall include an empirical case study based validity testing of the potential coupling areas identified in Table 1.

5 Conclusion

This paper presents the results of a literature review on what entails the ‘Nordic approach’. The aim of this literature review process was to explore how a good understanding of the ‘Nordic approach’ can inform research on DfS implementation. The paper begins by defining the ‘Nordic approach’. Further, it sketches out different characteristics of the Nordic countries and how these contribute to the Nordic style of functioning in firms. The paper argues that a joint reading of the Nordic approach and the challenges in implementation of DfS provides valuable insights to streamlining the latter. It also discusses how these characteristics help in addressing barriers and challenges identified in the DfS implementation literature. Potential research areas in this topic are also discussed.

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PAPER III. UNDERSTANDING PERSONAS

- Authors:** Faheem Ali, Casper Boks, Niki Bey
- Full Title:** An exploration of Company Personas to support DfS Implementation
- Published in:** Proceedings of ICED 2017
- Purpose:** Explore the concept of “company personas” similar to “user personas” as used by designers for understanding the end user of their products and services. By doing that, also to identify what characteristics of a user persona will be relevant while defining a “company persona”.
- Method:** Review of literature on persona discourse in various fields and its characteristics as identified from different empirical studies in existing literature.
- Results:** It was established that the concept of “company personas” is an interesting proposition to the ongoing discourse on solving non-technical and human side challenges affecting DfS implementation. A initial framework on different characteristics of company persona is also presented.
- Contributions:** Six major group of persona characteristics relevant for defining a “company persona” was identified and discussed in the light of DfS implementation challenges. Similar to user personas, “company personas” can get consultants, researchers and DfS proponents closer to the case company they are working with and address the contextual issues of that particular company.



AN EXPLORATION OF COMPANY PERSONAS TO SUPPORT CUSTOMIZED DFS IMPLEMENTATION

Ali, Faheem (1,2); Boks, Casper (1); Bey, Niki (2)

1: Norwegian University of Science and Technology, Norway; 2: Technical University of Denmark, Denmark

Abstract

The increasing discussion on DfS implementation in companies has shifted the focus to effectiveness of the implementation process. Literature shows that there are certain barriers and challenges that impede the success of such efforts. This paper tries to explore whether companies – similar to product users – have certain personas that play a determining role in the implementation process. The paper draws its theoretical foundation from academic literature on human persona in user-centred design and DfS and from environmental management system literature on company characteristics. This is supplemented by insights from interviews with a case company trying to identify dimensions of a company persona in a DfS implementation context. These results are used to propose an initial framework to define persona of a company.

Keywords: Design for X (DfX), Ecodesign, Persona, Case study, Human behaviour in design

Contact:

Faheem Ali
Norwegian University of Science and Technology
Department of Design
Norway
faheem.ali@ntnu.no

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1 INTRODUCTION

Design for sustainability (DfS) implementation in companies has been receiving increased attention in academic literature in recent years. Various authors have proposed tools, methods and approaches to streamline and guide the DfS implementation process in companies. However, a review of these tools and methods points towards low level of usage (Bey et al., 2013) of these in industries. Further, studies also identify major barriers and challenges to DfS implementation in companies (Baumann et al., 2002; Boks, 2006; Stevels, 2007; Dangelico, 2015). More recent papers on the topic also observe the same trend in DfS challenges (Pigosso et al., 2013; Ramani et al., 2010). Some of these papers stress upon the need to consider the human side aspects in organisations implementing DfS strategies and undertaking DfS projects (Boks, 2006; Verhulst and Boks, 2012; Brones, 2017).

Further, studies also argue that success of sustainability implementation in companies varies based on the context and capabilities of the company. These include factual aspects, such as size, industry branch, geographic location, and history of the company. In addition, DfS implementation may be affected by a multitude of factors existing within and beyond the company boundary. These could include for example the place in the hierarchy of the supply chain, which affects the potential to collaborate and negotiate up and down the supply chain and with other partners such as knowledge organisations. This will affect access to both human, financial and physical resources. Further, organisational culture may also affect DfS implementation project. The internal factors could include the way DfS is communicated, empowerment and involvement, resistance to change, the commitment towards sustainability, differences in expectations from the project outcome by different departments and stakeholders involved, the prioritisation of DfS projects within the overall company portfolio, overall strategy and long term vision of the top management etc. The maturity level related to experience with dealing with DfS implementation will also determine how this is best done in practice (Pigosso et al., 2013). The existence of a wide variety of contexts makes it likely that successful DfS implementation will have to take this into account, and that prescribing 'off the shelf' approaches that do not take into account the variety of contexts will essentially be meaningless. It is attractive to draw parallels with user centred design approaches that focus on understanding the customer (or end-user) in order to offer a commercially attractive value proposition. With DfS implementation strategies being the value proposition, the companies are the customers (or end-users) that will need to be understood well in order to offer an DfS implementation strategy that is attractive to use.

These observations lead to the proposition that companies, as product users, will possess non-factual characteristics that distinguish them from others; but at the same time, there will be companies that operate in similar contexts. If we assume this, it is interesting to attempt to identify what characteristics may be relevant to distinguish, what dimensions will they entail, and if they can be measured in a meaningful way. This is the starting point of this explorative paper, where the aim is to gain insight in the feasibility of constructing 'company personas' that will facilitate DfS implementation. A company persona is tentatively defined as characteristics of the company in functional, organisational, business strength and value chain dimensions that distinguish the company or corporate from the rest, or enables it to be grouped with other similar companies.

To inform this process, we have taken insights from existing literature on personas and explored how these can contribute to such a discussion. Additionally, some existing literature has tried to identify the different contextual aspects of DfS implementation in companies and how it may impact the success or failure of the DfS project. This includes the change management perspective for eco-design implementation in companies (Verhulst and Boks, 2012), an exploration of regional characteristics of organisations and its impact on DfS (Ali et al., 2016), and the maturity level and preparedness of the companies in terms of sustainability implementation (Pigosso et al., 2013). This paper is an attempt to take these discussions on the role of human side factors of organisations in DfS implementation further. The authors approach the case by presenting academic view points and insights from industrial interviews on how identifying and defining the "persona" of an organisation may help us better develop tools, methods and approaches. The data presented in this paper is primarily based on academic literature on personas in design and organisational theories.

1.1 The Persona in literature

The origin of the persona as a research topic is widely found in user centred design literature, where the user becomes the main focus of the design process. Persona as a technique for designers was introduced by Alan Cooper in 90's in his book titled, "*The inmates are running the asylum*". In the book, Cooper observes that designers often have unclear or vague ideas of the end user of the product and are most often driven by user scenarios similar to the designer himself/herself. To overcome this shortcoming, Cooper suggests the "goal-directed-design", where multiple user centred research methods such as interviews, ethnographies etc. are combined with market research, user requirements and goals to better define the user and his/her needs (Cooper, 1999).

For this paper, personas are defined as user classes fleshed out into "user archetypes", that gives the required precision to the design activity of the designer. The popular support for personas come from its advantage over scenarios due to close proximity to the reality of the design goal and the engaging nature of personas (Grudin and Pruitt, 2002). Personas help design teams in thinking about users during the design process, make efficient design decisions without inappropriate generalization, and facilitate communicating about users to various stakeholders (Matthews et al., 2012).

Outside design literature, extensive discussion on personas and the various dimensions of it can be found in software development literature as well. Rönkkö et al., (2004) observe that personas also bring social and political aspects into focus. The following chapters in this paper tries to identify the different dimensions of persona as discussed in literature and how it can potentially contribute to identifying organisational persona.

1.2 Organisational style and theories

Literature on company or corporate personas as an overarching concept is limited, and appears to be mainly oriented towards the company's image in the view of customers. In this case, corporate identity, company associations or company profile are the preferred terms of use. Literature, mostly in the branding and marketing domain, distinguishes ways to describe different types of corporate identity can be distinguished (including actual, communicated, conceived, ideal, and desired corporate identity (Balmer and Greyser, 2002), and that customers may have company associations related to for example organisational effectiveness and social performance, which may be linked to corporate ability and corporate social responsibility (Brown and Dacin, 1997). But in our present discussion on how to define company personas, we feel that corporate identity, company associations or company profile is one of many aspects making up a company persona, rather than a synonym for it, and should be understood as identity, association or profile in the eyes of the customer. We are however searching for a persona that describes the company, or even departments within it, in terms that are useful for the researcher (or consultant for that matter) in recommending approaches for successfully implementing projects or operations, in this case in the context of Design for Sustainability.

Elements of a company persona, in the context that we choose to see it, obviously relate to "company culture" or "organisational culture". These will be in particularly relevant in the context of successful implementation of Design for Sustainability, and are addressed separately in this paper. Literature on these topics do provide further granulations of what culture is made up of, but also this literature does not list these elements of culture next to, or in addition to, characteristics of the company that describe aspects not related to culture. This is why a grounded research approach to conceptualise such descriptions appears to be most relevant in the present case.

2 RESEARCH METHOD

This paper aims to take an explorative approach towards finding an operational description of a 'company persona'. It does so by attempting to identify the different aspects and characteristics that may be relevant to describe a company persona. The focus of our work is on aspects and characteristics that are relevant within the context of sustainability implementation. The overall research process is divided into three stages as illustrated in the figure below.

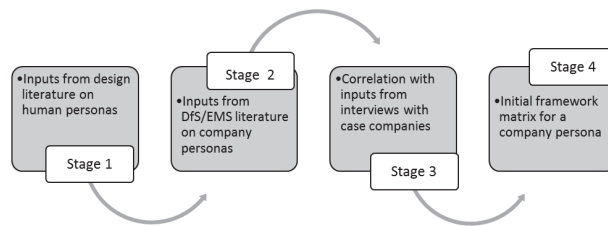


Figure 1. Research method followed

Stage 1 reviews existing literature on personas in order to identify the general characteristics of person mentioned in literature on persona and other user centred design studies. The aim here is not to transfer this to a company context without question, but to explore if elements that are used to describe human personas can also be applicable, in an adapted way or not, to company personas. The second stage explores literature on Dfs implementation and Environmental Management Systems (EMS) to identify the different characteristics of a company that may affect sustainability implementation in companies. Based on inputs from the first two stages, the third stage builds on interviews with case companies. In this stage, the interviews were analysed to 1) identify if the identified potential elements of a company persona are possible to 'measure' through an interview, and 2) to analyse if additional elements could be identified to supplement the elements found so far. The final stage builds upon the initial stages to present an initial framework matrix to define the persona of company from a Dfs perspective.

3 RESULTS FROM LITERATURE REVIEW

3.1 Stage 1: Inputs from design literature on persona

Existing literature on personas suggests that the primary aim of using personas as part of a design activity is to overcome the risk of developing a generalised solution for users. By using personas, designer attempts to identify and visualise the actual requirements of the users, by defining a fictitious character or entity that would resemble the final target audience or user (Faily and Flechais, 2011). In a design activity, often several personas are developed in parallel to account for different demographics, user requirements, norms and values, etc. Firms with extensive design activity often use the same, extensively described personas across many different design projects. In many cases, these often represent particular contexts of the users, but not too extreme users (Faily and Flechais, 2011; Long, 2009).

Miaskiewicz and Kozar (2011) use the Delphi technique to rank the benefits of using a persona identified from literature. The 1) audience focus- where the end user of the product is the main focus, 2) product requirements prioritisation - on product requirements and ensuring that the right problem is being solved, 3) audience prioritisation - bringing about a focus on the most important audience, and 4) challenge assumptions - that are often incorrect about the users/customers are some of the top benefits identified in that paper. Further, literature also observes that the creation of personas has made communications in design environment easier and more explicit. The efficacy of driving the debate and arriving at design decisions made the technique popular among designers. Political and social characteristics of users remained mostly unaddressed in earlier design cases, and the persona enabled scenarios for recognizing and challenging these characteristics (Chapman et al., 2008; Pruitt and Grudin, 2003; Rönkkö et al., 2004). Using personas helps to create an embodiment of the needs and goals of the users thus providing additional specificity and avoiding the higher level of abstraction in the definition of the user (Blomquist and Arvola, 2002).

Floyd et al. (2008) identify the different kinds, attributes and characteristics of personas based on existing literature and case studies. They categorise the persona technique into seven major kinds, based on the detail of description, intended purpose and what kind of data is sourced to create a persona. The first classic kind of persona identified by Floyd et al. (2008) is the one proposed by Alan Cooper, it relies on in-depth ethnographic research and tries to create as many initial personas as possible (Cooper, 1999). Floyd et al. (2008) further observe that in "Cooperian" style of personas, the initial personas developed to capture the basic understanding of user characteristics are then merged through analysis to arrive at one primary persona for each user kind. These final personas are then maintained throughout the rest of the design process and discarded at the end of the project. Floyd et al. (2008) classify these Cooperian personas into two kinds, Cooperian Initial Personas (CI) and Cooperian Final Personas (CF).

The second type of persona belongs to Pruitt and Grudin, which is characterised by its massive data driven approach, quantitative and qualitative. The personas so developed are then retained even after the project is completed (Floyd et al., 2008; Grudin and Pruitt, 2002). The third kind of persona identified by Floyd et al. (2008) is Sinha personas, which are data driven, primarily quantitative but less comprehensive in comparison to the other kinds (Sinha, 2003). The article further explains three other personas kinds namely ad hoc, user archetypes as personas and marketing personas. The ad hoc persona is derived from intuition and experience of the designer but discarded after the design cycle is complete. The user archetypes are similar to personas, except that they are more generic and cater to a larger group of audiences than personas. It is less precise compared to a persona, thus also qualifies with more general information. Dantin (2005) studies the user archetypes intended for two online platforms, outlining the general public targeted with the service, making it "elastic" (Floyd et al., 2008) and describing several people simultaneously.

Since the focus of this paper is on company personas and how it may facilitate improved DfS implementation in companies, the authors believe that a mix of inputs from user archetypes, experience and qualitative data will contribute to the purpose of this paper. The characteristics of these personas are further enlisted in the following sections.

3.1.1 What does a persona entail?

Faily and Flechais (2011) identify three main steps in creating a persona, firstly, summarising the proposition by identifying the thematic propositions that the persona shall address. Secondly, enumerating and explaining the characteristics identified for the persona. Finally, creating detailed narratives of the persona characteristics and other supporting narratives.

Considering these principles while reviewing the persona case studies in literature, we could identify a predominant number of examples from the software field that tend to define the characteristic of the user being targeted. Rönkkö et al. (2004) identify certain characteristics for a case company where persona as a design technique was used but failed to overcome the design challenge. These characteristics include the demographics of the company, the field of work, their expertise in the field, years of experience, department structure etc. The article however notes that the persona technique failed because it did not take into account the external environment of the company, stakeholders outside the company. Matthews et al. (2012) observe that despite its limitation, this shows the power of persona as technique in bringing out the "some irreconcilable differences between various design stakeholders". The authors believe that while defining the company persona, explained in detail in the following sections, it should include characteristics both external and internal to the company for successful implementation of DfS.

Further, Cooper (1999) notes that each human persona has a work environment, socio-economic dimension and demographic dimension of culture, ethnicity or race to it. Pruitt and Grudin (2003) further elaborates on these by looking into a set of dimensions in the case example, this include goals, fears and aspirations of the user, market size and influence, knowledge, skills and abilities, communication, views and opinions, attitude towards the solution/product etc. Thus, the literature review was able to highlight a number of characteristics that can potentially be transferred from human persona to define the "company persona" terminology. These characteristics are illustrated in Figure 2.



Figure 2. Identified potential dimensions of a company persona - an illustration

3.2 Stage 2: Insights on company persona from DfS and EMS literature

In order to support the discussion on "company persona" in the context of DfS implementation, it was imperative to look into the relevant literature on DfS implementation in companies that discuss the

"softer-side" of companies. In one of the earlier works on the "soft-side" of DfS, Boks (2006) mentions a set of characteristics that companies need to emphasise during the implementation stage. This include communication structure, need of cooperation between companies, alignment of needs and expectations between proponents and executors, establishment of market demand for DfS products etc.

More recent works on DfS implementation also highlight similar requirements for companies, such as top management commitment, empowerment of employees and better change management facilitation (Doppelt, 2003; Verhulst and Boks, 2012). Dealing with 7 "sustainability blunders" in companies, Doppelt (2003) suggest that companies need to restructure their strategies, their way of organising sustainability strategy team and ensuring alignment in the vision and activities of the team as a first step to create a sustainable enterprise. Further, studying the role of resistance against sustainability and internal communications in sustainable design implementation in companies, Verhulst and Boks (2012) highlight the need for different communication styles that will inform, support and involve the employees of the company.

Further, studying the different existing DfS tools and their usage in the industries, researchers observe that these tools are seldom used due to certain barriers in the companies. These include the lack of overview of the knowledge capacity within the company, insufficient resources and commitment from management and absence of clear environmental information (Bey et al., 2013). Further, lack of integration of DfS and corporate strategy (Pigosso et al., 2013), difficulties in defining and planning the activities for DfS implementation, challenges in prioritizing the eco design practices in companies (Boks and Stevels, 2007) etc. also add to these barriers. Researchers who studied the external environment of the company and the role of stakeholders from a sustainability implementation perspective identify the need of stakeholder involvement and management of the stakeholder relationship both internally and externally (Aschehoug et al., 2012; Bocken et al., 2014).

Literature from Environmental Management Systems (EMS) identifies certain characteristics of companies for successful implementation of EMS systems, namely;

- Organisational culture supporting sustainability focus (Daily and Huang, 2001; Linnenluecke and Griffiths, 2010).
- Training and skill sets for understanding sustainability issues and EMS systems (Daily and Huang, 2001; Sarkis et al., 2010).
- Recognition for team work and rewards culture in organisations for sustainability initiatives (Daily and Huang, 2001).
- Effective communication flow between employees and the top management (Madsen and Ulhøi, 2001).

Reading these desired company characteristics for successful DfS/EMS implementation along with characteristics of human persona identified from literature in Stage 1, confirms the idea that it is interesting from an academic standpoint to explore, identify and attempt to define a company persona from a DfS perspective.

3.3 Stage 3: Insights from interviews

A third 'source of inspiration' has been in the form of interviews with a case company. These interviews were done in the context of a broader research project, but are used here to identify characteristics of a company persona that can be observed in a real case DfS implementation project. The case company A operates in the Fast Moving Consumer Goods (FMCG) sector and is an industry leader in some of its product categories. A total of 8 semi structured interviews were carried out with employees who have responsibilities related to sustainability. This included people from both top management, project managers and product developers/designers in 2 major business units of the company (referred in the Table 1 as BU X and BU Y).

The interview questions focused on the nature of DfS implementation in the company and how different organisational characteristics identified from the literature and also discussed earlier in the paper influenced the implementation process. The second half of each interview tried to identify and frame the persona of the company using an organigram outlining the functional style of the company and the various dimensions of it. A final part of the interview tried to elaborate on characteristics of company persona that were not identified from literature, if any.

The major themes discussed in the interviews and the observations relevant to the topic of this paper is summarised in table

Table 1. Insights from the case company interview

Sl.	Theme	Quotes	Key elements for persona definition
1.	DfS implementation style	<p>"We have a stage gate model that is quite uniform to a large extent, but since we are a decentralized company, we do not have a formalized manner for eco-design implementation. But we have guidelines and an agency as an internal consultancy with best practices, guidelines etc. But this a model we suggest and it is up-to companies to select and apply the guideline" (CSR Operational Manager - Top management)</p> <p>"we don't have any tools or standardized formula when it comes to DfS. We are not there yet, and I want us to be there. We have started that discussion on what should be our main setup." (R&D Head - BU Y)</p>	Level of formalised manner for DfS implementation
2.	Top management	<p>"I would wish if the top management would be a bit more concerned about sustainability and...yeah the...future of our business" (Product developer - BU Y)</p> <p>"it doesn't matter if the CEO is motivated (sustainability issues), if the management team under him does not have that commitment.."</p>	Extent of top management commitment
3.	Communication	<p>"the communication with R&D is actually very good, as we have project teams, and there are representatives from all the departments in the project team" (Procurement manager - BU X)</p> <p>"we are very used to working with each other, so we adjust our technical language so other department people can understand" (Project manager - BU Y)</p>	Existing communication style in the company
4.	Culture in the organisation	<p>"when listening to companies that are doing really good in sustainability, they have a purpose on why they are doing it. But we don't have it in our culture, we have a vision. But that does not have sustainability in it. We are missing that part in our culture and that should come from top management. We have an attitude that we need to do the job and get money for our stakeholder" (HSE - Top management)</p>	Level of culture promoting sustainability
5.	Organisational structure	<p>"we are quite hierarchical and everything takes time. So for example when we need to have a sustainability strategy, we will need a budget and it takes may be 4 months before we get to know if we will have the money or not. So it is very bureaucratic..." (Product developer - BU X)</p>	Organisational structure existing within the company
6.	Use of tools and methods	<p>"we don't have tools or any methods for DfS as of now, and that is probably something we should have wanted by now..." (Product developer- BU X)</p> <p>"We are making use of tie-ups and partnership with university B for developing better sustainability solutions in our products, as we lack the complete internal expertise right now" (Product developer - BU Y)</p>	Level of DfS tool usage, skill set and knowledge on sustainability
7.	Empowerment and Decision making	<p>"we are reliant on the top management for most important decisions, so we are driven by finance department and the top management. So we don't have so much decision making in this case." (Product developer - BU Y)</p> <p>"if we would have our sustainability strategy as part of our business strategy, then that is something we would like very much to have. Because then it makes it very much easier to take decisions, which is good for environment or social conditions. And now it becomes a fight between departments before we try to do it" (Project Manager - BU Y)</p>	Level of empowerment and decision making power to employees
8.	Market position in company	<p>"we have pressure from our customers to be more sustainable, but our market share is quite high which makes that the pressure from the customer is not that strong enough" (Project manager - BU Y)</p> <p>"we have a strong sustainability focus in our raw material procurement, however, it is difficult to ensure that the suppliers comply with requirements, as we are a small procurer by their scale in some products. This restricts our power" (CSR Operational Manager - Top management)</p>	Level of market dominance and hierarchy in the supply chain, related to power to change status quo

4 DISCUSSION

As observed from both the literature and the interview results, we believe that there is sufficient potential for studying the persona of a company and for proposing what entails a company persona. This is of particular interest from a DfS implementation context as the success of a DfS implementation project varies widely based on the company context. Hence, having an understanding of the company context will be important in order to be able to cater for it.

The literature review and interview findings show that there are certain observable company characteristics that play a determining role in DfS implementation. This range from the top management commitment to sustainability to the knowledge base and skill set present in the company. Below, we present an initial framework matrix that groups the company characteristics identified from DfS and EMS literature under broader categories drawn from human persona and user centred design studies.

General Persona Category	Persona Details	Observed from literature	Observed from Interviews
Company background and activities	Goals		X
	Sustainability prioritisation		X
	Resource	X	X
Demographics	Overall strategy	X	X
	Culture	X	X
	Tools/methods usage	X	X
	Push for creativity	X	
Structure	Training/skill set	X	X
	Empowerment	X	X
	Tools/methods development	X	X
	Geographic/Co-location of departments		X
	Communication	X	X
Market conditions	Participative management style	X	
	Market conditions	X	X
	Awareness/customer demand for DfS	X	X
Political undertones	Position in supply chain	X	X
	Commitment/consensus/conflict resolution	X	
	Work distribution/ Fear to change	X	
	Team work/incentives	X	

Figure 3. Stage 4: Initial framework on defining a company persona

These characteristics are then matched towards what could be identified from the literature and what could be identified from the interviews. Such a framework was devised with primarily three aims, firstly, can the human persona be transferred into a company context, secondly, how can the findings from DfS and EMS literature enrich such a categorisation and finally, by providing a cross comparison of the results from literature and interview, can the latter be further enriched to elicit more content from companies to better define the company persona. As observed from the matrix, we could identify certain persona dimensions that were exclusively identified in the literature or the interviews alone. This provides food for thought on contributing to existing literature on DfS implementation and company characteristics.

5 CONCLUSION

The paper presented an overview of how inputs from literature on human persona and desired company characteristics from DfS implementation and EMS literature can help identify possible dimensions of a company persona that will help better cater to the contextual needs of a company during DfS implementation. Results from a case company interview was also discussed to find the correlation between the findings from literature and actual company situation. From the initial framework discussed in the paper, we feel that it is possible to use interviews as a tool to determine what company persona is relevant for a particular company. However, the interview results presented here are not conclusive on its own, as it is based on only one particular company. Hence, the potential future work could include building detailed persona descriptions based on more detailed interviews with more companies. Further

research can also include proposing advisable approaches on DfS implementation to companies based on their determined persona.

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PAPER IV. EXPLORING COMPANY PERSONAS

- Authors:** Faheem Ali, Raphaëlle Stewart, Casper Boks, Niki Bey
- Full Title:** Exploring “Company Personas” for Informing Design for Sustainability Implementation in Companies
- Published in:** *Sustainability*, 2019
- Purpose:** As a follow up on our earlier study on “company persona”, this study brings in insights from empirical studies to present a more concrete picture on what constitute a company persona and how it can be constructed.
- Method:** Empirical data from 16 interviews in seven Norwegian and Danish case companies, along with data from four additional interviews with sustainability experts to validate the findings from case companies.
- Results:** Two broad categories of “company persona” characteristics identified as extrinsic and intrinsic respectively. These two categories were further granulated to seven persona dimensions each that can potentially define a company closer and better under the overarching theme of DfS implementation. Steps to construct a company persona is presented along with a discussion on how this contributes to existing studies on DfS implementation.
- Contributions:** Contextual factors that differentiate one company from another was highlighted and persona was proposed as a concrete measure for consultants, researchers and company management to identify these niche organisational characteristics and thereby to take a customised approach to DfS tool and method development.

Article

Exploring “Company Personas” for Informing Design for Sustainability Implementation in Companies

Faheem Ali ^{1,2,*} , Raphaëlle Stewart ^{1,2} , Casper Boks ¹ and Niki Bey ²

¹ Department of Design, Faculty of Architecture and Design, NTNU Norwegian University of Science and Technology, 7491 Trondheim, Norway; rste@dtu.dk (R.S.); casper.boks@ntnu.no (C.B.)

² Division for Quantitative Sustainability Assessment, Department of Management Engineering (DTU MAN), Technical University of Denmark (DTU), 2800 Kongens Lyngby, Denmark; niki@dtu.dk

* Correspondence: Faheem.ali@ntnu.no; Tel.: +47-9412-2067

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Abstract: The need for understanding the context of the case company during Design for Sustainability (DfS) implementation has been a long identified need among the researchers in the field. Yet, studies on company context have primarily focused on studying, enlisting, and prescribing standardized solutions for companies or clustering companies based on similarities. Such approaches have not been able to overcome the organizational “soft side” challenges that have been long addressed in DfS literature. This explorative paper takes insights from 20 case interviews conducted in Norwegian and Danish manufacturing companies and with sustainability experts and uses the concept of persona from design studies to explore the potential of defining “company personas” to better define the context of the company. The interview analysis produced 14 dimensions, including both hitherto identified factual needs of companies and soft-side elements required to create a company persona, thereby informing practitioners and researchers to take a DfS implementation approach tailored to the company context.

Keywords: Design for Sustainability (DfS), eco-design; persona; case study; implementation; industry; Nordics

1. Introduction

The need for sustainability considerations in product design and development processes has been gaining greater acceptance in industries. One of the initial responses to including environmental concerns in product development was termed as eco-design or design for environment [1], which mainly had a product focus. In the past 25 years, the field went through several transitions [2] and gradually expanded in focus to incorporate sustainability, service, and business perspectives, and is now commonly referred to as Design for Sustainability (DfS). This transition also paved way for academic discussion to widen the scope of DfS to include the socio-spatial context of the product design in addition to environmental concerns [3], including service perspectives (PSS) [4] and business [5] perspectives. Even though the concept of DfS has been a focus subject in both academia and industry, academic reviews suggest that DfS implementation has faced a number of barriers and challenges in actual implementation stages [6]. Addressing these challenges, a part of academic discussions focused upon the contextual factors existing within and beyond the company boundaries that could have a possible impact on successful DfS implementation [7]. Solutions put forward by academia to overcome these challenges have been mostly in the form of standardized DfS tools, checklists, and matrices [8]. However, most of these solutions have failed to create desired results or have not been widely used in industry [9]. This is mainly because most challenges and enablers for DfS implementation vary

depending on the context of the company, and standardized solutions are less likely to be effective in such situations [7,10].

Some studies in the DfS literature have focused on highlighting the contextual differences that exist within companies involved in sustainability implementation [11–13]. Domingo et al. [14] presented one such case study based on two companies where the context of the companies was characterized using a three stage process, namely mapping the company's business context, identifying its key development areas, and developing an eco-design introduction plan. The characteristics identified included the management structure, product development process in the company, environmental knowledge in the business, strategic focus of the company, business drivers for DfS and its feasibility, and the role of the company in the value chain. Elsewhere, researchers clustered companies into sustainability leaders, environmentalists, and traditionalists based on their approach to sustainable development [12]. With an exception of Domingo et al. [14], these mentioned studies primarily focused on clustering the companies based on commonalities existing in its company context and sustainability preparedness. In a later study, to assess companies based on their sustainability readiness, Pigosso et al. [8] proposed a sustainability maturity model for companies that looked into the level of formalization for eco-design implementation, the capability level existing within the company, and the steps to progress to higher maturity among others. While the maturity model prescribed an in-depth path of progression for companies in the sustainability journey based on its capabilities and eco-design evolution, the prescriptions were often unidirectional in nature, irrespective of the companies' human and social factors. Even though such an approach provides general recommendations on how companies can progress, the authors of this paper believe that uncovering niche characteristics of the company will complement efforts from researchers in addressing DfS implementation challenges. Thus, this paper aims at placing itself at this conjunction between importance of company context and hitherto the lesser-addressed "soft-side" (human and social factors) of DfS implementation.

Such a balanced approach can be seen in design literature, where designers aim to provide design solutions that better fit to the needs of their product users by identifying the distinguishable characteristics of the users and collectively addressing users with similar characteristics as "personas". User personas used in design processes provide a close description of the targeted user, his/her aspirations, and what he or she aims to achieve from the product or service being designed [15,16]. Chang et al. [16] observed that user personas can be made for just one person in mind, as proposed by Cooper [15], or it could be an aggregation of user characteristics of similar stakeholders that present a "mash up" of people [17]. Drawing from this area of design research and combining it with the aforementioned DfS implementation scenario, we assume that companies, as product users, possess certain characteristics that distinguish them from others; and on the other hand, there are companies that are comparable to each other in terms of their operational internal and external contexts. If we assume this, it is interesting to attempt to identify which characteristics may be relevant to distinguish from a DfS perspective, which dimensions they will entail, and whether—and in what manner—those dimensions can be identified in a comprehensive manner. This is the starting point of this explorative paper, where the aim is to gain insight into the feasibility of constructing "company personas" from a sustainability perspective with the possibility of eventually using these personas to facilitate choices related to which DfS tools and methods may be most suitable for that company, and how they can be implemented best. For this purpose, a company persona is tentatively defined as an archetypal set of characteristics of the company in functional, organizational, business strength, and value chain dimensions, which can be used to distinguish the company it is projected on from other types of companies or to enable it to be clustered with other similar companies. Drawing parallels from academic and design studies on user-based (or end-user) design strategies—where the user occupies the center stage in the design process—this paper proposes the idea of placing the company in the center focus of academic research on mitigating DfS implementation challenges. As design practitioners often resort to the "user persona" as a design method to facilitate user centered design approaches, this paper investigates the "company persona" in a similar way.

In order to better inform this process, the paper firstly presents the theoretical background of personas from design literature and explores how this can contribute to such a discussion. Secondly, the paper discusses the existing literature on DfS implementation that has tried to identify the different contextual aspects of companies, and how they may influence successful DfS implementation in companies. Finally, the literature findings are corroborated with results from 20 semi-structured interviews carried out with seven different companies that have a DfS focus in their product development and with four sustainability experts who have worked with DfS implementation in companies. This paper aims to further discuss the role of contextual factors of organizations in DfS implementation. The authors approach this case by presenting academic view points and insights from interviews with industrial actors on how identifying and defining the “persona” of an organization may improve development of tools, methods, and approaches for integrating sustainability considerations in design processes. The paper thereby also aims to explore the potential of future prescriptive research that can be placed in between generalist and customized approaches. Theoretical research is often accused of lacking practical application potential, and general guidelines for DfS implementation may lack relevance for individual companies due to the different contexts they operate in. On the other hand, customized approaches (such as those based on individual case studies) may lack the potential of generalization and applicability beyond a single context. It is our hypothesis that zooming in on a company persona level when developing a company-specific approach avoids disadvantages that exist on either side of this spectrum. The targeted audience for the use of such “company personas” is mainly twofold; firstly, there are the sustainability/eco-“champions” in companies or proponents of sustainability initiatives who can use it as a self-reflective tool in the implementation process, and secondly, there are the scholars and sustainability consultants working towards improving DfS adaptation and implementation in companies.

In summary, this paper explores the potential of constructing “company personas” in a similar vein as “user personas” based on dimensions that characterize the company and assesses thereby their potential contribution to developing tailored DfS implementation approaches.

2. Theoretical Framing

The following section presents findings from a traditional literature review [18], carried out to explore the importance of context of the company in the DfS implementation scenario, and insights from user persona literature to guide the discussion presented in this paper. The literature search was primarily carried out using Google Scholar and the Scopus database. As the interest of this paper lies in exploring user personas from a practitioner’s perspective, additional inputs from case studies available on online webpages and blogs by designers were also included.

2.1. Persona Origin, Definition, and Dimensions

The origin of the persona as a research topic is widely found in user centered design literature where the user is placed in the center of the design process. Alan Cooper introduced persona as a method for designers in late 1990s in his seminal work titled, *“The inmates are running the asylum”*. In the book, Cooper observes that designers often have unclear or vague ideas of the end user of the product and are most often driven by user scenarios similar to the designer himself/herself. To overcome this shortcoming, Cooper suggests the “goal-directed-design”, where multiple user centered research methods such as interviews, ethnographies, etc. are combined with market research, user requirements, and goals in order to better define the user and his/her needs [15]. For this paper, personas are defined as user classes fleshed out into “user archetypes”, which gives the required precision to the design activity of the designer.

2.1.1. Benefits of Using Personas

The popular support for personas comes from its advantage over scenarios due to close proximity to the reality of the design goal and the engaging nature of personas [19]. Personas help design teams in

thinking about users during the design process, make efficient design decisions without inappropriate generalization, and facilitate communicating about users to various stakeholders [20,21].

Miaskiewicz and Kozar [22] used the Delphi technique to rank the benefits of using a persona identified from literature: first is audience focus, where the end user of the product is the main focus; second is product requirements prioritization, which regards product requirements and ensures that the right problem is being solved; third is audience prioritization, which brings about a focus on the most important audience; the last benefit is challenging assumptions that are often incorrect about the users/customers. These are some of the top benefits identified in that paper. Further, literature also observed that the creation of personas made communications in design environments easier and more explicit. The efficacy of driving the debate and arriving at design decisions made the technique popular among designers [23]. Political and social characteristics of users remained mostly unaddressed in earlier design cases; however, the use of personas helped in recognizing and challenging such characteristics [23–25]. Using personas helps to create an embodiment of the needs and goals of the users, thus providing additional specificity and avoiding the higher level of abstraction in the definition of the user [26].

A common application of the persona tool is observed in IT system implementations in companies, where we could identify a predominant number of examples that tend to define the persona characteristic of the user being targeted. Rönkkö et al. [25] identified certain characteristics for a case company where persona as a design technique was used but failed to overcome the design challenge. These characteristics included the demographics of the company, the field of work, their expertise in the field, years of experience, department structure, etc. The article, however, notes that the persona technique failed because it did not take into account the external environment of the company, e.g., the stakeholders outside the company. Mathews et al. [21] observed that, despite its limitation, the power of persona as a technique lies in bringing out “some irreconcilable differences between various design stakeholders”. The authors of this paper believe that while defining the company persona, which is explained in detail in the following sections, the definition should include characteristics both external and internal to the company for successful implementation of Dfs.

2.1.2. Creation of Personas from Design Literature

Faily and Flechais [20] identified three main steps in creating a persona; firstly, summarizing the proposition by identifying the thematic propositions that the persona shall address. Secondly, enumerating and explaining the characteristics identified for the persona. Finally, creating detailed narratives of the persona characteristics and other supporting narratives.

Floyd et al. [27] identified the different kinds, attributes, and characteristics of personas based on existing literature and case studies. They categorized the persona technique into seven major kinds based on the detail of description, the intended purpose, and what kind of data are sourced to create a persona. The first, classic kind of persona identified by Floyd et al. [27] is the one proposed by Alan Cooper, which relies on in-depth ethnographic research and tries to create as many initial personas as possible [15]. Floyd et al. [27] further observed that in the “Cooperian” style of personas, the initial personas are developed to capture the basic understanding of user characteristics and are then merged through analysis to arrive at one primary persona for each user kind. The final personas are maintained throughout the rest of the design process and discarded at the end of the project. Floyd et al. [27] classified these “Cooperian” personas into two kinds, Cooperian Initial Personas (CI) and Cooperian Final Personas (CF).

The second type of persona is the kind used by Pruitt and Grudin, which is characterized by its massive data driven approach, both quantitative and qualitative. The personas developed this way are retained even after the project is completed to be used and adapted in future projects because of the data backed approach [19,27]. The third kind of persona identified by Floyd et al. [27] is Sinha personas, which are also data driven (primarily quantitative) but less comprehensive in comparison to the other kinds [28]. Floyd et al. [27] further explained three other types of persona, namely ad hoc personas and

marketing personas. The ad hoc persona is derived from intuition and experience of the designer but is discarded after the design cycle is complete. The user archetypes are similar to personas except that they are more generic and cater to a larger audience than the designer's extreme user personas. It is less precise when compared to a persona, thus also qualifies with more general information. Dantin [29] studied the user archetypes intended for two online platforms, outlining the general public targeted with the service and making it "elastic" [27], describing several people simultaneously.

Further, Cooper [15] noted that each human persona has a work environment, socio-economic dimension, and demographic dimension of culture, ethnicity, or race to it. Pruitt and Grudin [23] further elaborated on these by looking into a set of dimensions in the case example that included goals, fears, and aspirations of the user, market size and influence, knowledge, skills and abilities, communication, views and opinions, attitude towards the solution/product, etc. Extrapolating these observations from the different characteristics that encompass a user persona in the company context and perceiving companies, like humans, as "organisms" who strive for survival and recognition, it is reasonable to assume that companies also likely possess characteristics that distinguish them from others. In order to further guide this research on what these likely company characteristics could be in DfS context, Section 2.2 elaborates on research findings from earlier studies that looked into the contextual issues encountered during DfS implementation in companies.

2.2. Design for Sustainability Implementation and Relevance of Company Context

As stated in the introduction, academic research on DfS increasingly acknowledges the need to address the overall socio-organizational context of the company in addition to the technical details that DfS projects demand [30–33]. These include the change management perspective for eco-design implementation in companies [33], company characterization based on the business features for eco-design activity planning in companies [14], and managerial motivations behind sustainability activities [12], among others. Companies need to emphasize their communication structure, their need of cooperation between companies, the alignment of needs and expectations between proponents and executors, and the need for the establishment of market demand for DfS products in addition to focusing on the technicalities of the products [34]. Lack of integration of DfS and corporate strategy [8], difficulties in defining and planning the activities for DfS implementation, and challenges in prioritizing the eco-design practices in companies [35] also add to these barriers. Companies often need strategic visions and policies with an accompanying viable business case to prioritize and drive integration of DfS in its product development activities [12,30,36]. Research has also shown that senior management should ably support DfS initiatives by performing regular follow ups [37], making compulsory contributions in terms of guidance and resources [14], and providing flexible environments that promote innovation on sustainability topics [38].

Further, researchers who studied the external environment of a company and the role of stakeholders from a sustainability implementation perspective identified the need for stakeholder involvement and management of the stakeholder relationship, both internally and externally [39,40]. Engaging with external actors on sustainability topics can provide a great learning experience for companies [5] and increase the feasibility for such projects [37]. Internally, it is important for companies to align DfS initiatives with overall product lifecycle management to encourage participation from all departments [41] and thereby garner clarity in the DfS implementation process [42]. Dealing with seven "sustainability blunders" that companies usually commit in eco-design implementation, Doppelt [38] opined that ways of organizing sustainability strategy teams and ensuring alignment in the vision and activities of the teams are the first steps to creating a sustainable enterprise. Companies also act as communities with their own aspirations, ambitions, beliefs, and hardships in different contexts, thus warranting differential treatment [43]. The DfS activities they undertake need external stimulus for generating a consistent demand for sustainable products. This should be integrated in the actual project management process within the company in order for it to be successful [30,37]. Johansson [31] also mentioned the need for regular and recurring environmental assessment in all stages of the

Product Development (PD) process. In addition, a number of other factors existing within and beyond the company boundaries—such as the position in the value chain, and its influence or capability to integrate, collaborate, or negotiate higher or lower in the hierarchy of the value chain—may also affect how DfS implementation can best be approached. Elsewhere, while studying the role of resistance against sustainability and internal communications in sustainable design implementation in companies, Verhulst and Boks [33] highlighted the need for different communication styles that inform, support, and involve the employees of the company. Parallel to the discussion on the “soft-side”, there has been significant research focus on DfS tools and methods, which have been primarily quantitative in nature but with a few exceptions of semi-quantitative or qualitative tools [44]. However, the uptake of these tools is marred by the need for specific knowledge to use and understand the results [31], the oversimplification of certain results [44], the overwhelming number of tools to choose from [8], and the lack of envisaged market opportunities for eco-design products [45]. Hence, it is evident that most often, the “off-the shelf” solutions such as Life Cycle Assessments (LCA), design matrices, design for X solutions, checklists, and tool-based prescriptions offered to DfS challenges are likely to be ineffective or at least insufficient without a customized implementation plan.

Thereby, these factors that exist within the company context and have an established influence on the DfS implementation scenario in companies, as summarized in Figure 1, warrant attention from the researchers working to improve a DfS implementation process. Personifying companies and approaching these contextual factors as defining characteristics of companies underlines the hypothesis presented in this paper that companies, when seen as customers for as users of a DfS implementation strategy, can be represented by personas. Relating this to characteristics stated in Section 2.1, there is a clear connection between how these different factors of company context can be employed under the persona methodology. The following sections present the insights from empirical data collected and data analyzed to further explore this understanding.

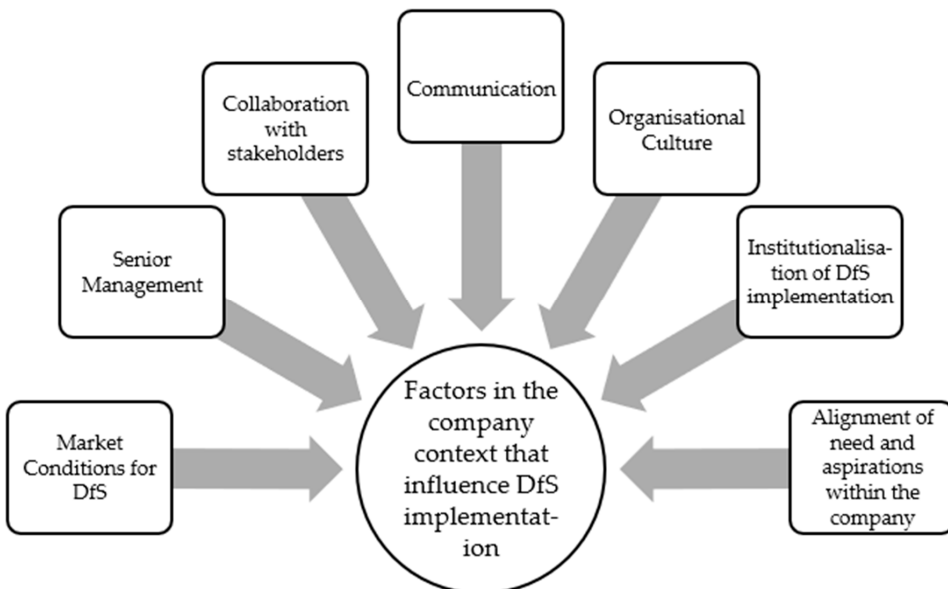


Figure 1. An illustration of different factors in the company context that influence the Design for Sustainability (DfS) implementation process as identified from literature.

3. Research Method

The research methodology adopted in this paper is outlined in Figure 2. It was inspired by the case study approach presented by Yin [46] and Cassell and Symon [47], which began by framing the boundaries of the case, collecting the data, analyzing the data, and leaving the case study by relating the findings and their implications to the existing body of knowledge.

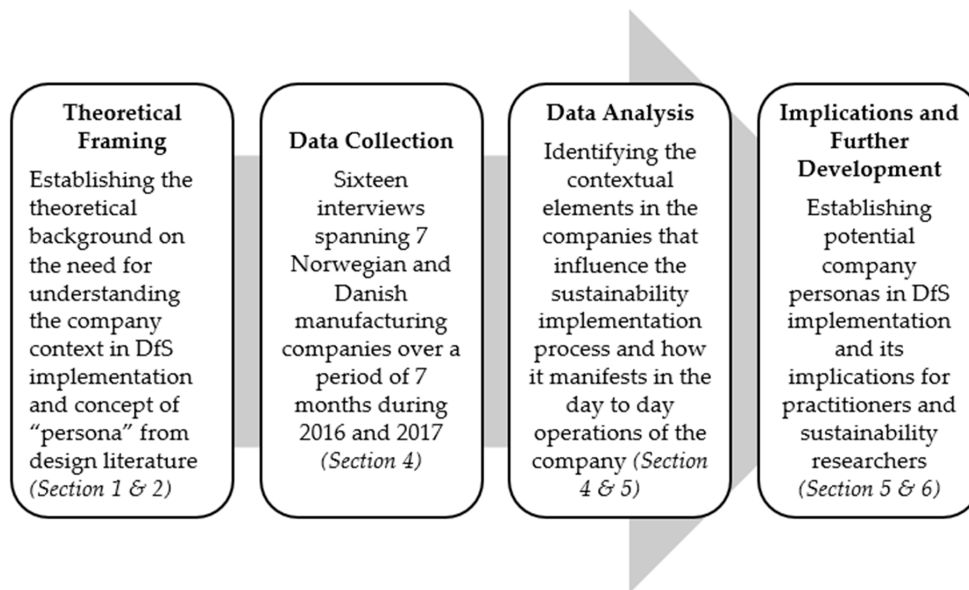


Figure 2. Outline of the research methodology.

3.1. Case Interviews

The sixteen case interviews were carried out in seven Norwegian and Danish manufacturing companies that had a sustainability focus in their product development and clearly outlined sustainability goals in their official communication in the form of annual financial and sustainability reports. There is no prescribed number of cases that should be included in a case study research, but having four to ten cases is advised [48]. The companies were selected on the basis of convenience sampling, either through earlier established contacts with companies, or based on accessibility to the case with limited resources and within the time frame [49]. However, the companies were listed based on predefined criteria that looked for manufacturing companies based in Scandinavia, companies with existing DfS focused products in their product portfolio, and companies with in-house product development activities. Thereby, the seven companies interviewed in this study present a homogenous sampling of companies with certain specific characteristics [50]. Additionally, four interviews were carried out with sustainability experts in the field of eco-design implementation for validating the findings from case companies. Among the interviewees from the case companies, seven respondents and their departments were directly involved in sustainability activities to a large extent as part of their work. Among the other departments that were represented in the interviews, product developers and project managers formed the next biggest group. The functions of other respondents varied between communication directors, EHS (Environment, Health and Safety) personnel, and R&D managers. The details of the respondents and case companies are further detailed in Table 1. The interviews were aimed at corroborating the literature findings and enriching them with real case experiences of implementing sustainability strategies in the product development and with statements of how the company context influenced the overall implementation process. Given the explorative nature of the

study, semi-structured interviews were a judicious choice [46]. The interview questions were aimed at eliciting insight from the respondents into how DfS was implemented in the product development activities in the company, which factors in the company context influenced the implementation process, and how interactions within the company and between the company occur regarding the external actors on sustainability issues.

Table 1. Interview respondent details, case company background, and number of interviews. EHS = Environment Health and Safety, R&D = Research & Development, CR = Corporate Responsibility, PM = Project Management.

ID	Company/ Respondent Group	Industry	Major Business Region	Number of Interviews	Respondent Background
A	Pouch	Medicare supplier	Global	3	A1: EHS A2: EHS A3: PM
B	Microbes	Biotechnology	Global	1	B1: Sustainability
C	Watt	Renewable energy	Global	2	C1: EHS C2: EHS
D	Wood	Construction	Global	2	D1: Sourcing D2: Product regulations
E	Vitamin	Health care	Scandinavia	2	E1: Communications E2: Sourcing
F	Food	Consumer Goods	Global	2	F1: EHS F2: CR
G	Soap	Personal Care	Scandinavia	4	G1: R&D G2: R&D G3: R&D G4: Marketing
SE	Sustainability Experts	-	-	4	SE1: Consultant SE2: Consultant SE3: Researcher SE4: Researcher

In order to further complement the data collection process and enrich the information gathered from case company interviews, we used an interaction mapper (Figure A1) that was designed to help the respondents graphically organize their thoughts, thus overcoming some of the commonly identified challenges in interviews such as losing the context of an answer [51], having difficulties verbally communicating one's ideas [52], and factually disconnecting what they say and what they mean [53]. As can be seen from Figure A1, the map consists of five different boxes for actors, the central actor being the interview respondent and the four other boxes marked as Actor 1, Actor 2, Actor 3, and Actor 4, which denotes the departments or entities (external and internal) of the company with whom the respondent interacted during a DfS project. The points listed under "Organizational Persona" were used to guide the respondent on formulating their responses. While using the map, the respondent was asked to identify a set of actors that their department interacted with when it came to a DfS implementation project. Then, they were asked to pick two to four major actors and highlight the different factors that influenced their interaction with those actors during the implementation process. The identified actors included personnel, departments, project groups, different management positions within the company, suppliers, competitors, and customers. Post-its were used to note the observations made by the respondents regarding the factors that influenced their interactions.

3.2. Interview Analysis

All authors of this paper curated the interview questions jointly, and two of the authors carried out the interviews. Each case company interview lasted between 60–90 min. The interviews were recorded and transcribed using the qualitative data analysis software NVivo. As stated earlier, a combination of both deductive and inductive approaches [54] was taken while analyzing the data. Contextual factors of companies that influenced DfS implementation, as presented in Section 2, were probed for in the deductive part of the coding activity. Additionally, factors that emerged from the interview data were coded and analyzed in the inductive approach. The coded entities included words, phrases, or complete answers to interview questions that had key elements pertaining to the company context and its influence on the DfS implementation process. The results of the coding process are presented in Section 4.

4. Interview Findings

The factors illustrated in Figure 1 were used as points of departure in exploring the different possible dimensions of a company persona from the interview data. Based on this, 14 different dimensions were identified as relevant while defining the characteristics of a company persona. As can be observed from Table 2, the inductive approach from factors identified in Figure 1 and the deductive coding approach of the interview data showed a certain trend in the characteristics of the dimensions, namely factors that were partly or fully influenced by happenings/relations external to the company and factors that were solely by the company's own function and style. Drawing inspiration from philosophy and metaphysics literature, these were categorized as extrinsic and intrinsic characteristics, respectively.

In philosophical studies, ascription of extrinsic characteristics to a product or entity is not entirely about the product or entity. Rather, it may well be part of a larger context in which the product or entity exists as a part [55]. In our context of companies, this could include factors external to the company that influence the company's activities, such as product offerings, value proposition, and strategies. Contrarily, a "sentence or statement or proposition" that ascribes intrinsic properties to a product or entity is entirely about that thing [56]. In our context, this translates to the internal organization of the company, the DfS implementation process, and the functional goals to DfS, among others. Some of the factors identified during the literature review in Section 2 were found to have different manifestations in the actual company setting and were therefore constructed under different dimensions in order to define the company persona better. For example, the role that senior management has in relation to DfS implementation and the approaches they take (or do not take) to materialize their visions (if any) were some of the important factors mentioned in the literature reviewed. Analysis of the interview data revealed the different possible implications of senior management in practice, such as Board of Directors (E1) and History of the Company (E6). Sections 4.1 and 4.2 explain how these 14 different dimensions—under extrinsic and intrinsic characteristics—were identified from the interview data.

Table 3 presents an overview of each dimension matched against the case companies where it was found to be an influential contextual factor in DfS implementation. These are marked as "x" in the table. Further, the final column of the table corroborates these findings with the inputs from sustainability experts (SE) who, based on their experiences working with companies, identified the most influential factors in a company involved in DfS implementation. As can be seen from Table 3, the identified dimensions have a certain level of interconnectedness among them. This is primarily because the company persona is a reflection of the company context, and the context is often dependent on factors that are important on their own, yet the context is also influenced by other factors of the company. For example, a company's strategic focus, product offering, and company history influence its market conditions. Hence, the results presented in the following sections are an outcome of a coding process that looked for such factors, both independent and dependent, in defining the company context and should be read within this context.

Table 2. Description of the dimensions identified from the interviews categorized under extrinsic and intrinsic characteristics. E = Extrinsic and I = Intrinsic.

ID	Source of Dimension	Dimension	Description
E1	Deductive	Board of Directors	The role of ownership and decision-making bodies in the company.
E2	Deductive	Value proposition of the company	The main value offered by the company through its activities, which could be consultancy, product, PSS, or service.
E3	Deductive	Drive of the company on DfS issues	The major driving factor in the company in the form of cost, Corporate Social Responsibility (CSR), legal compliance, philanthropy, or total sustainability.
E4	Inductive	Strategic focus of the company	The extent to which sustainability is part of the company's defined strategy and how it is emphasized in the decision making process in the company.
E5	Inductive	Market conditions	The market readiness, regulatory needs, demand for sustainable alternatives, existing and possible collaborations with actors in the value chain on DfS.
E6	Deductive	History of the company	The traditional business experience and values that influenced sustainability activity in the company such as existing product offerings and ownership focus on niche business areas that contribute to sustainability.
E7	Deductive	Risk sensitivity	Willingness of the company to prioritize experiments, launch DfS products, or take actions leading to sustainability goals while disrupting the status-quo.
I1	Inductive	Senior management approach to DfS	The steps taken by the senior management of the company in establishing, realizing, and supporting activities which contribute to the overall sustainability strategy of the organization.
I2	Inductive	Organizational constitution	The way the departments, personnel, and functionalities are organized within the company and DfS projects executed.
I3	Inductive	Degree of formalization in DfS implementation	The method in which DfS focused projects are conceived, planned, and implemented with or without the aid of formalized processes such as stage gate models or eco-design tools.
I4	Inductive	Sustainability understanding	Extent of sustainability awareness/perception in the company and the manner in which it is/is not being incorporated in the company's activities at both individual and group levels.
I5	Inductive	Sustainability definition	The way sustainability is defined, communicated, and operationalized in the day-to-day activities of the company.
I6	Deductive	Functional goals in DfS	Realization of sustainability goals of the company through targeted steps (leading to direct sustainability benefits) or rather incremental improvements in activities (leading to indirect sustainability benefits).
I7	Inductive	DfS chaperoning	The anchoring and leading role that drives sustainability in the company in the form of sustainability champions and departments.

Table 3. Overview of persona dimensions as identified as influential factors in case companies and as experienced by sustainability experts. Dimensions that were identified to be significant in the companies' DfS implementation context are marked as "x". E = Extrinsic Characteristics, I = Intrinsic Characteristics.

ID	Dimension	Company A	Company B	Company C	Company D	Company E	Company F	Company G	Sustainability Experts
E1	Board of Directors	x	x	x	x			x	x
E2	Value proposition of the company	x		x	x	x			x
E3	Drive of the company on DfS issues	x			x	x		x	x
E4	Strategic focus of the company	x	x		x		x	x	
E5	Market conditions	x	x	x	x	x	x	x	x
E6	History of the company				x			x	
E7	Risk sensitivity	x	x	x	x		x		x
I1	Senior management approach to DfS	x			x	x	x	x	x
I2	Organizational constitution in DfS	x			x		x	x	
I3	Degree of formalization in DfS	x		x	x	x	x	x	x
I4	Sustainability understanding	x		x	x	x	x	x	
I5	Sustainability definition	x	x		x		x	x	
I6	Functional goals in DfS	x	x	x	x	x		x	x
I7	DfS chaperoning	x			x	x	x	x	

4.1. Extrinsic Characteristics of the Companies

4.1.1. Board of Directors

Following our interviews with the SEs in the field, a prominent extrinsic characteristic that was identified by all four SEs was the role of the Board of Directors, especially in the context of medium and small-scale companies that are often family owned or partly owned by the workers. In such companies, SE1 and SE2 opined that DfS implementation in companies is a decision making process that necessitates larger commitments in terms of resources and time for the implementation process. Convincing the Board of Directors in most companies SE1 and SE3 worked with was the first step in establishing a sustainability strategy in the company. However, this characteristic was not evidently observed in the first cycle of coding case company interviews, primarily because they were all large companies. Nevertheless, following the observations from the SE interviews, the case company interviews were explored again for this dimension in a second cycle of coding, resulting in the findings presented below. For example, Company D, being a family owned company, had certain instances where family ownership roots of the company played an important role in sustainability issues, as can be seen from the quote below:

“Our stakeholder is a foundation that owns us and the family that established the company. And, as long as they agree with what we do, we are able to (sic). Moreover, we are economically sound company and we can put investments in to things we like to invest in. Of course we don’t have, I mean there are limited amount of money, but if we say, we want to do this and it is agreed upon by our board, we can go ahead and do it. Therefore, in that sense we are very fortunate and I know that the son of our founder he is not active in the business. However, he is very keen on these issues (sustainability). Him being there on the backseat somewhere, still overlooking what we are doing, that is also a big driver for us. And that is the charm of being in a family owned company as well.”

(D2—Wood)

On the other hand, other larger companies, such as Companies A, B, C, and G, had the senior management (including the CEOs) as the more prominent decision making entity when it came to implementation of sustainability in product development.

4.1.2. Value Proposition of the Company

Companies tend to focus on different value propositions in their activities, which range from Product-Service Systems (PSS) to consultancy services. The nature of this value proposition is another important factor that helps define the context of the company. As all seven case companies were manufacturing companies, their biggest value proposition was the product itself. However, as could be observed in Companies A and C, the product itself could connote different priorities for the company. In Company A, the product was intended to provide the best user experience for the customer and had user comfort as a priority:

“No, it (sustainability) is not a main part of our strategy, the main part of our strategy is to make it easier for our users. Actually, we have our mission, vision and values here. And this is really, what is important for the company. It is making life easier for people with intimate care needs.”

(A1—Pouch)

For Company C, in the renewable energy sector, the priorities were the efficiency of their product and the indirect sustainability benefit emanating from it in the form of lower cost, less wastage, easier transportation, and better functioning of the products:

“And you would see that we stand out looking into eco-design or what we found out is that development in our industry is driven by the levelled cost [. . .]. So all we do is to minimize the cost and we do that natural thing in PD is to have less material because you need to buy that transport that, service

that anything. So, that is the cost that every time we put a kilo on there is a cost associated with that. So Eco-design is not implemented in the way it is in some other businesses. Because [. . .] setting targets will be outdated in 2 years times because our engineers outperform the targets that we dare to set for them."

(C1—Watt)

Whereas consumer goods manufacturers like Companies E, F, and G focused on maintaining their performances with successful products, which was followed by introducing new sustainable alternatives or improving the existing products with respect to sustainability. Company B and Company C had more B2B (business-to-business) contexts, and the value propositions were quality products with certain indirect sustainability benefits, such as lower energy consumption and longer durability while using their products.

4.1.3. Drive of the Company on DfS Issues

Another significant extrinsic characteristic of the company identified was the drive of the company in sustainability activities. The case companies interviewed were invariably focused on the prices of their products and ensuring compliance with the legal requirements. Given the nature of the industry, the cost factor was more prominent in consumer goods companies such as E and G. Company E had strong influence from competition, making it more wary of the costs involved in the products, as can be seen in the following quote:

"But most often, if they (marketing and supply chain) don't find it most relevant for the consumers or so, it might be that it costs, and if we should really do that. But, if it is something that we have to do anyways (compliance), that is not part of this. This is more kind of questions where you actually have to go one step further. These kinds of projects I am talking about (that are not the common ones)."

(E1—Vitamin)

While in Company G, sustainability was very much linked to how it translated to increased sales:

"I think you can see that for management sustainability is important part. But if the link to that is to increase sales, it is a longer link. So, to be able to see that link, I think is important and we felt the link tougher than may be how they have seen it."

(G2—Soap)

At Company D, even though cost was the most important driver in the company, there were certain product development projects under process where the sustainability (in the form of material and energy consumption) was prioritized over other factors:

"Many of our PD projects have energy performance as their only focus and then you have quality, delivery, price and then you have some market relevance like color, sizes or whatever. But energy performance is the main in eco-design. And that is formalized very much so. We have colleagues in R&D dept. who work on it."

(D2—Wood)

In addition, other major factors driving companies on sustainability were identified from the interviews with experts—namely philanthropy (SE 2), CSR initiatives (SE3, SE2), compliance with legal and regulatory norms (SE1, SE3, SE4), and total sustainability in its activities (SE4, SE3). None of the case companies were found to have an existing total-sustainability agenda.

4.1.4. Strategic Focus of the Company

Defining a clear sustainable strategy often helps companies in prioritizing DfS activities [29]. However, the interview results show that defining such strategies could range from general statements

to setting clear operational goals in the day-to-day functioning of the company. Company B was observed to have clear goals and targets on sustainability topics and ensured that these were followed up at each stage in the company's product development process. Such an approach helped the company in prioritizing sustainability issues and in decision making related to product development practices:

"I do think that it is the right approach (to have strategic focus). Because, if it is not a top down, it is really hard. It is really hard to go bottom up, I can tell you from experience. Of course you can try to push in the doors, but without management commitment. [. . .] So, if you are not being told that this is your target and this is your agenda, you need to make sure that you develop some sustainable product or you engage customer on these topics, you won't prioritize it."

(B1—Microbes)

Whereas Companies E and G had sustainability goals and targets, as communicated from their corporate level, and needed to translate those to match their product development activities. This translation often needed more resources to tailor the corporate level strategy to the company level:

"I think the key is the understanding and strategic planning for this, it is what is lacking, for us because we have worked on and have launched just before summer our sustainability strategy which said about where we are going. So when we have a structure which says about where we are going, you can all go in the same direction and make tools and good goals for going in that direction. In addition, that has been lacking last years. So we didn't know where we wanted to go and it is hard to get funding when you don't have a plan and a reason for why you need it."

(G2—Soap)

The interview results also showed that certain companies could spend considerable time and resources in developing a consensus around the sustainability strategy of the company, as was the case with Company F. This mutual understanding of setting sustainability targets and goals helps companies incorporate them more systematically into each department's activity and overcome the challenges associated with sustainability understanding in the company, as highlighted in Section 2. Such an approach to sustainability strategy also equipped Company F to provide general guidelines to its departments—rather than rigid structures—thus providing the latter with sufficient freedom to operationalize the sustainability strategy as per its context:

"First solution was to develop the sustainability strategy. Which we did through a very thorough process. I think we actually spent 1.5 years on this strategy process. We involved of course all the functions, but also all the key persons in the companies. So then, the strategy was sent to be approved by the board of directors. So then, when we had agreed on the targets, it was easier to go with a specific agenda to the management teams of the business areas of the companies."

(F2—Food)

Another company characteristic observed in sustainable strategies was how the business context of the company influenced the priorities of the company in relation to sustainability topics. Given the unique customer base of Company A (mostly patients with serious illnesses), despite acknowledging the need for more sustainable product solutions, the company had a clear focus on prioritizing the user experience above all the other aspects. Such a focus also awarded Company A a formidable position in its market:

"And I think that (sustainability strategy) basically boils down to what you think. I think the major part of the work we do here, is because, we like to make people better and help them the best we can. So that will basically change what you are doing. On the other hand, we are looking to substitute some of the worst candidates away. On a long term."

(A3—Pouch)

4.1.5. Market Conditions

As all the interviewed case companies were manufacturing companies, the market conditions surrounding their product offering were found to have strong influential roles in the DfS implementation process that was adopted. Companies such as E, F, and G experienced a strong pull for greener products from their customers, necessitating changes in the product portfolio of the companies. Another aspect observed regarding market conditions was the strong role that marketing and sales departments play in highlighting and driving new initiatives in companies. As the marketing department forms the interface between the company and customers, they have a bigger say in project meetings. In Company G, the marketing department was always the project manager in all product development projects:

“I work closely with them (marketing department). So, at the moment, they have, they see the need in the market and there is the white spot on sustainability. So for them also to, they are very enthusiastic when you are presenting solutions to them. Moreover, I think it is good communication that makes it also easier and I have worked with marketing so I see also their struggle. I know what they are facing and what they need in a way.”

(G2—Soap)

In certain other company contexts, such as in Companies A and B, the utility and efficiency of the product was most demanded for, and the product development activity was fine-tuned to ensure that those issues—as flagged by their respective customers—were addressed. This included better durability of their medical products, ease of use and disposal, ensuring high quality, and ensuring a low risk of product failure in the case of Company A. Similarly, in Company B, such demands translated to adaptive solutions in biotechnology that could be used for the specific needs of customers (companies), such as lowering energy requirements and increasing the efficiency of the end products. Such requirements necessitate that Companies A and B choose suppliers that can ensure a sustained supply of raw material for a long term over smaller suppliers that can supply sustainable alternatives:

“Always this high in (product development) process is the (importance of) whole supplier demand. As in, we would like to have materials that can be readily sourced, so if it is more likely to have more sourcing options, that could also be one way that we say, OK, there is potentially an environmentally better option here. But if it is only a small supplier and it is only one in the world, whereas there are two large suppliers that can supply us, we might actually decide to go with the one and based on the fact that we would like to have the steady supply of materials.”

(A3—Pouch)

Another important market condition that was observed in Company D was the high price competition that exists in the construction industry. Thus, the customers of Company D had more alternatives to choose from, making them more conscious of the price rather than the sustainability credentials of the product. Therefore, the company must look for more sustainable alternatives without increasing the price of their products to a level that is unattractive to the buyers:

“I had actually some workshops with our market people here and it’s not that our market (is green conscious), that our way of selling things is not really (based on) a green stamp or a green swan. It (eco-labelling) is not anything that can bring our sales up or can justify a higher price. If you have two products and the price were the same, then the customer would choose the one with the green stamp. But the customer from our market sales’ perspective, our feeling is that customers are not willing to pay (extra) for a product with a green stamp.”

(D1—Wood)

4.1.6. History of the Company

A few of the interviews highlighted how the history of the company was a factor in the sustainability activities of the company. At Company C, the primary business model is to develop and deliver products that cater to renewable energy production. The indirect benefit stemming from this business, according to one of the respondents, is greener energy in the world and a lower carbon footprint. Thus, the historical trend existing in the company has been to make its products more efficient in delivering more energy output in the use phase of the product:

“It’s (eco-design) already happening without it being called eco-design or before we are setting targets specifically to reduce waste. Coming in from a cost-target perspective in getting this level-ised cost of energy down and somehow our product is being innovated in ways that also have an add-on benefit for the environment (green energy) so there is not the need to do these eco-design projects (specifically) because so much is already happening.”

(C1—Watt)

Similarly, at Company D, the product offering has helped in improving the indoor living quality of commercial and residential buildings. A focus on improving the indoor living quality has been a primary focus of the company right from its beginning, translating indirectly to sustainability benefits for the end user of its products. Such an approach encourages both Companies C and D to further work on the technicalities of their product. However, it does not necessarily create a need to reduce the footprint of the production process or to look for more sustainable raw materials in the product development process:

“It (Sustainability in Product Development) depends a little bit how you look at it because if you say eco-design project, we have a lot of focus on the properties of our product. [...] So in that terms we have a lot of focus on the eco-design if you look at it in the way that we produce products that will save energy in your house so it’s a little bit how you look at it because that has a great focus through the whole project. So, that’s my point and it is the whole idea about our products actually so that is a very natural thing that is the driver (for DfS) in our products.”

(D1—Wood)

Interestingly, as mentioned in Section 4.1.4, at Company F, the focus on sustainability is rather recent and the company is working on operationalizing its sustainability strategy. Nevertheless, as pointed out by one of the interview respondents, the presence of harmful chemicals and hazardous raw materials necessitated that Company F look for safer and more consumer friendly alternatives before establishing a sustainability strategy. This underlines the relevance of company context and history when considering product offerings and sustainability issues:

“We have a long history of product development to reduce their environmental impact. So that is not something that is new to them (and has existed before the sustainability strategy). And earlier I guess, it has been the Product Development Department. or a similar department like it (that had an) important (role) in putting this on the agenda.”

(F2—Food)

4.1.7. Risk Sensitivity

Risk sensitivity was another important topic discussed during the interviews. The interview analysis showed that risk sensitivity of the companies related mostly to the external environment of the company, specifically in relation to its responses when compared to competitors and market conditions. Consequently, risk sensitivity is an extrinsic characteristic in the company persona. The case companies tended to take a “watch and replicate” approach when it came to launching new DfS products in their markets. Some of the respondents identified the following reasons for such an

approach: the inherent risk of losing their existing customer base, the huge initial investment involved in developing and marketing new products over existing ones, and the lack of short term returns or results. This is very rightly reflected in the following quote from Company D:

“But when it comes to doing something new, taking risk, adding cost, the answer is no [. . .] So that is why it’s complex. It is not like a problem because they (senior management) are very supportive. The management really wants to do the right things, also about thinking green. But it’s always a balance, and uh a balance of risk if you go into new things, new materials.”

(D1—Wood)

Further, the companies were also concerned about the long-term investments the project needed and the risks involved in being the first mover on environmental issues and investing in DfS:

“This project “X” we had, that was with a lifetime of 30 years, which is very long, and that was why that fell to the ground, because OK 30 years, we don’t know whether we would have those sites in 30 years. So, that was way too long. So, I think if I can come up with a project with a payback time before 2020, I think that will go through, but that is not the case at the moment.”

(A1—Pouch)

“That is how we see it and we don’t have to be front runners and sometimes that is a good when you are looking at environmental issues. Because it can be very expensive to be the front-runner. Moreover, when you are doing projects/products that have a long lifetime. Like, you don’t want to put something in your home that might damage in half a year right? It is expensive; you do not buy that many products in your lifetime.”

(D2—Wood)

Consumer goods companies such as Companies E, F, and G often based new product launches on their ongoing product development processes or looked for successful solutions from larger players in other geographic markets in the rest of Europe and the world. These observations from the interviews point to the need for evaluating the risk-taking nature of the company while also understanding its context from a DfS implementation perspective.

4.2. Intrinsic Characteristics of the Company

4.2.1. Senior Management Approach to DfS

The way the senior management in the companies approached the topic of sustainability was found to have a meaningful impact on the whole implementation process. All the case companies that were interviewed invariably acknowledged the need for sustainability in their activities and mentioned that their senior management also held similar views. However, this commitment from senior management towards sustainability implementation was observed to be different in each of the companies. While some of the case companies already had very well established positions in senior management that focused on sustainability activities, others had it embedded with other management responsibilities, presented as a sub task for the EHS department. At Company F, the sustainability strategy was developed in close association with the senior management, which made anchoring the sustainability activities much easier in the group and the business units under it:

“They have used time to develop their own sustainability strategy so I think it has been a very good process together with them and the whole management team involved with the work. It has been much better anchored with the management team.”

(F1—Food)

While at Company A, given the nature of its products and its priorities of providing better service to their customers, the management often prioritized using the best material possible for their products, and sustainability was only indirectly prioritized in the product development process:

“But in the end, if your alternative gives a less good user experience, then you have to prioritize between what you are doing...so in that sense, that is why I said there is a lot of conflicts. Because we have these kind of situation (market case) and as long as we are within the boundaries of what we are doing, are we use rules and discuss with our colleagues that we do the correct choices, or the best choices, then basically they are OK with that.”

(A3—Pouch)

Not having the necessary senior management support and follow up often made it difficult for companies to proceed with the implementation of sustainability aspects in their products. This also meant that the senior management needed to be updated on the changes being implemented and how they delivered economical and environmental returns to the company. A case example from Wood can be seen in the following quote:

“By the end of 2014 we started the analysis [. . .] and we addressed assessing Circular Economy (CE). Our management group, they are like, 6 of them I think, half of them forgot what they had approved. So they were like... NO you shouldn't do CE and we had a lot of a big hurdle to get this analysis started. So, it (the senior management) was a very complicated group to handle because they are management, they have a lot of opinions, they are very fast. They don't have time to actually sit down and listen to context or... On the other hand, if you don't have their acceptance on what you are doing, you will get nowhere.”

(D2—Wood)

Further, some of the senior managements were strongly driven by “the global sense of economics”, i.e., unless there was a clear business plan for any investment being made on sustainability topics, it would be hard to prioritize DfS in the company's activities. These observations definitely underline the importance of understanding the role and attitude of senior management in sustainability topics in a company while trying to define its company persona.

4.2.2. Organizational Constitution in DfS Activities

Another important extrinsic dimension observed from the interviews was the way people and departments were organized in the company. Some of the case companies had sustainability departments that oversaw all sustainability activities in the company, whereas others had sustainability as part of the R&D department in the company or embedded in the EHS department. Having a complete overview of sustainability activities helped companies push for the changes needed in product design and development more easily than when it was just an additional task within R&D or EHS. At Company B, the sustainability development group that was anchored as part of the senior management oversaw the sustainability activities. This bridged the communication gap between the sustainability activities in the company and the strategic decision making process happening within the senior management of the company:

“I think that (to be anchored within senior management) has been an advantage, allows us to work across. Which is really super important. I don't really know where else should we be really anchored. Of course, I would think we could be anchored in project management or in marketing. But that would make it more difficult for us to work across the depts. Like in any environmental/ sustainability department, we need to work across.”

(B1—Microbes)

Company G had a very top down management style where the decision making was time consuming and the lack of overview and absence of a sustainability department often made it difficult to communicate the importance of different sustainability actions to the management:

“Yeah, that (department constitution) is one thing and also we are quite hierarchical (sic) so, every decision takes a lot of time. Moreover, when we are trying to have, for example. sustainability strategy,

we would need a budget and when it takes may be 4 months before you get an answer whether we can have the money or not, because it is all this layers."

(G1—Soap)

At Company F, the senior management provided guidance on sustainability matters to the different business units below it and thus followed a decentralized structure on DfS implementation:

"Then it is a decentralized structure. So I, don't have authority, we don't want to be normative. Nevertheless, we want to inspire, guide and discuss with each companies' management team. But at the end, what a unit does will be decided by the management team of that company. So in order to implement the sustainability strategy, there is a need for all of these departments."

(F2—Food)

At Company C, the flat cross-functional teams collaborated closely with each other on DfS projects, making it easier to learn from each other and communicate the expectations from projects among themselves more effectively. Such a flat structure of project teams also helped the company bridge the communication gap between project teams located at different offices of the company:

"You have a directional system for products, for marketing, for manufacturing and in those directional systems you have managers that go across different functions to coordinate. So of course we have a hierarchy, but we don't have to go up and then go down to get a decision from the management. We can go directly from our department to another and say, well because this and that we have to do like so. So, it is a flat structure."

(C2—Wood)

4.2.3. Degree of Formalization in DfS Implementation

Researchers earlier mentioned how the level of formalization can influence DfS implementation in companies [31,57]. The interviews showed that each of the case companies approached DfS implementation differently. A major distinction can be drawn between the formalized and in-formalized approaches to DfS implementation. Stage gate models, checklists, feedback loops, and additional tools (such as LCA in the PD stages) supported the formalized approach. Setting general guidelines and requirements, ad-hoc measures, and client dependent evaluations of the product's sustainability characterized the informal approach. At Company B, LCA was used early in the product development phase to provide a rough estimate on the environmental impact of the product and later again in the stage gate process to evaluate the actual impact of the process. However, these steps are also client dependent in some cases, and the respondent mentioned the need for ensuring that it is followed in all project teams unanimously:

"We have a much formalized process here, so called stage gate model. The development projects are being set up that way all. [. . .] LCA is integrated in that process. We have two entry points, one at the very early stage. [. . .] As soon as the concept is ready in early stage, we usually enter into the project and try to make these initial assessments. Because already at an early stage it could be beneficial for the project to know if we have a very good sustainability story here? But once we had identified in the early stage that we have some sort of sustainability benefits, then we can pursue these during product development and make sure that we collect wide range of LCAs to take place towards the end (of stage gate process)."

(B1—Microbes)

Meanwhile, respondents from Companies E, F, and G mentioned a more informal approach to DfS implementation. As mentioned earlier, Company F had a practice of providing guidance on DfS projects rather than strict structures for the implementation process. The respondent also mentioned how they provided support on LCA for the company's units who wanted to carry out an analysis

based on the sustainability guidelines provided to them. As Company F was in the early stage of DfS implementation, this need-based approach was a good start for the company, rather than enforcing eco-design tools for all projects:

“It’s like setting the directions for the company, giving guidelines or giving requirements from senior management to over units (sub-business units) and how to work with and what we mean should be in place. It is like setting the directions for them, giving guidelines or giving requirements from the senior management to over organizations and how to work with and what we mean should be in place. Yeah there have been questions from some of the units about doing like life cycle assessment. That’s where I have been involved to support them in how to do this, to find out how to do it, could there be someone that can support them and to understand more the theories behind using those types of tools.”

(F1—Food)

At Companies E and G, the respondents observed that there was a need for eco-design tools and methods, as well as a need for competence within departments to use it. The companies were in the early stages of their sustainability journeys and found it difficult to operationalize their strategies without sufficient resources in the form of tools and methods:

“No tools or any standard formula, we don’t have it. We are not that far, we want to be there. I hope we come there. We started that discussion what should be our main setup, if to be honest every single project should include one or another element where we take care of sustainability. It might be environmental, health or combination. But we are not there today, but we have several projects going on having environmental elements.”

(G3—Soap)

“As it has been so far, it has been mostly about convincing the right people, but what we want to have is to agree to (certain structure). When we choose people to do this (DfS) projects, we choose different departments and the relevant ones. Therefore, what we want to do is a sort of 4–5 guidelines that you should always consider in an innovation process or communication or other things, you should always consider that. [...] Therefore, I think that is the starting point. But, when it comes to seeing how we can be more effective, that is where we could be more eager, or have higher expectations on ourselves, to deliver more on being through sustainable choices. So it has been more ad hoc in the way we have introduced these subjects, but what I really believe in is that, we have to write a lot of theses. You don’t succeed in doing do it, if you don’t have it as part of the structure. What kind of question should you ask when you come this kind of product? Yes, you should ask these, these and these questions and those sustainable questions that should in that level. So that the different departments have to go through that gate. Are we willing to take a kind of reputation risk or do we want to see that X or Y happens? So that we are responsible (in DfS projects). And I think that natural or routine guidelines in that level is important, if not it is more accidental.”

(E1—Vitamin)

Thus, the level of formalization (or lack of it) in DfS implementation in companies was found to be an important intrinsic characteristic in defining the company persona.

4.2.4. Sustainability Definition

Another important characteristic observed in the companies was how the term sustainability was defined within the company context. At Company D, the respondent opined that terminologies such as Design for Sustainability or eco-design were not commonly used in the company, thus often created an ambiguity in the usage of the phrase in project teams:

“And we could also continue developing the language that we use about it. Because when you say “eco-design projects”, it’s not a word we use in here (at the company). So we could work further on a common language because there are many different words flying around in the media, but what is actually a green product or a sustainable product? What is it actually? It is very different what people understand by that.”

(D1—Wood)

At Company F, the respondent received requests from units on how to proceed:

“It has been overwhelming for us, taking sustainability on-board. So they (units) are asking me, what do you want us to do? Please tell us there are so many topics, we don’t know what to do and what should we focus on. So, that was actually why we tried to develop the common sustainability strategy to try and define all the different topics and make it easier.”

(F2—Food)

Further, in the interviews with sustainability experts, SE4 opined that there is a difference between the definition of sustainability and understanding what it means in a company context. Often, well-defined and communicated sustainability goals are not understood in the same manner among the employees due to the differences in educational background or individual perceptions. This difference was also observed in the case company interviews and is further elaborated in Section 4.2.5.

4.2.5. Sustainability Understanding

The interviews showed that, most often, the way sustainability was defined in the companies could be understood differently by different departments or individuals in the company. Another aspect to this was the awareness surrounding sustainability topics and how it was acknowledged in the product development process. F2 mentioned how it was difficult to convince and talk with colleagues about the need for integrating sustainability a few years ago, and how it changed recently with clearer goals and increased awareness in the company:

“I talked with them (colleagues) four years ago but this (increased awareness) is something new which I think makes it easier now. Because now I know where I am going, I know that I’m going to launch a product with recycled materials. Hence, it’s easier to discuss with them, they’re already in that area and have a lot of competence, and I need that competence and understanding to make it work.”

(F2—Soap)

At Company B, sustainability was very much top-down driven and was successful in imbuing DfS focus in product development practices. However, Company B also lacked a comparable understanding of sustainability issues within departments that were on the “business side” of the company, such as sales and marketing:

“I think we have been, that we have integrated the way (for sustainability), or may be in the past, there wasn’t this intensity with the corporate sustainability standing alone, sitting in the ivory tower. I think we are definitely working towards bringing sustainability more out at the practical side in the business. That is where it can be a huge challenge. I think we have managed really well in the PD. May be next step is to manage equally well with the marketing department.”

(B1—Microbes)

At Company E, due to the absence of a common understanding on sustainability topics, it was difficult to convince and educate departments on the certifications needed and raw material selection criteria pertaining to sustainable sourcing:

“So it (sustainability understanding) is more about wider areas to cover. So, if you talk about sustainability in total about the raw materials here, there are many (sustainability) factors (involved).

To get them (departments) understand better what is the difference between those and why is it not possible to have one certificate or some raw materials is difficult currently."

(E2—Vitamin)

4.2.6. Functional Goals in DfS

A general trend observed in the case companies was the situational versus planned and systematic improvements on the sustainability activities of the company. Company A resorted to making situational improvements to their products potentially possible without disrupting the utility of the product. Such an approach was needed for the company given its niche business area, as explained earlier:

"We don't have any formulated target on environmental improvements in the process, other than we want to evaluate it and we want to you can say we want environment to be part of the decisions. But we have not defined that we always want to take the greenest solution per se. And this is our main driver. And if we can combine that with a good environmental solution then we would like to do that. But the main driver is the solution. So that is really our passion. So it's actually more the social part you could say. That's the driver."

(A2—Pouch)

At Company D, a new organizational unit was formed exclusively to source for new raw materials to replace the existing ones in their products. Sustainability was also included as one of the evaluation criteria in this new sourcing process:

"This spring, I was changing my position from the development department to a new part of our organization, where we want to be a little more ahead of the development in terms of finding new materials or combinations of materials that can be used for new products."

(D1—Wood)

4.2.7. DfS Chaperoning

Another important intrinsic characteristic was the entity that drives the sustainability activities within the company. We termed this DfS chaperoning and found it to be eco-champions in companies, certain departments or indirect stimuli from external actors in the form of Non-Governmental Organizations (NGO), or environmental activists and consultants. Companies acknowledged that these entities with high motivations played important roles in establishing, executing, and following up sustainability goals in the companies. At Companies D and A, this was observed to be individuals pushing bottom up for sustainability focus in the company. These eco-champions pursued the sustainability agenda actively in the product development process:

"So I think it's a movement (sustainability focus), it's something that is maturing along as we get more knowledge. Putting the focus on sustainability, building it in in the presentation that we show to the management. Yes I would say that it is individuals, there are also some specialists that have a green focus that contribute so yes I would say it is individuals (chaperoning the process)."

(D1—Wood)

A1 narrated a similar incident in the following quote:

"I try to give a speech in a start-up project, I ask for 5–10 min, where I deliver the main issues that could be from our yearly environmental report. But it could also be like mass flows, pointing out the importance of environmental issues. Ok, we produce so much waste, but the waste we produce PD has been the same since 5–10 years ago. That is because we still produce these products and they still involve these waste. So, that is my key point, OK, so we really like to reduce waste and energy consumption is important for our whole CO2 account. It is now that we have to do it."

(A1—Pouch)

While at Companies E, F, and G, this was found to be external stimuli in the form of international collaborations with environmental agencies or companies themselves acknowledging the need for it along the whole value chain:

“As an administrative body we collaborated with the UNDP. So we developed together a project description, a concept description of the different types of activities that we believed needed to be taken in order to really lift the sector (sustainability in the whole value chain).”

(F2—Food)

5. Discussion and Analysis

The use of personas in design projects and research helps in bridging the gap between the actual and presumed needs of the user. The use of personas is intended to inform designers on how to target their design activity. The extreme user archetypes sketched using personas help get the designer closer to the actual user [15]. Translating this to the context of this paper, company personas should help researchers and consultants in sketching and understanding the user, or in our case, the company, better and more closely. Hence, it is interesting to understand how the 14 dimensions could equip this target audience with inputs on how to construct company personas. A user persona is typically based on characteristics such as the demographics of the user, fears and aspirations, needs and expectations, product use patterns, among others [15,19]. Similarly, the intrinsic and extrinsic characteristics observed from the empirical results provide a similar perspective of the company. Dimensions such as Board of Directors (E1), market conditions (E5), and the history of the company (E6) can be directly related to the demographics of a user. Similar comparison can be drawn between the views of the user [22] and risk sensitivity (E7), senior management approach (I1), emotional aspects, and DfS chaperoning (I7). These cross comparisons are further illustrated in Table 4. Therefore, based on the empirical results retrieved from the coding process, it is these 14 dimensions that can be corroborated with the user persona characteristics discussed in Section 2.

Table 4. A proposal for mapping commonly used user persona characteristics onto company persona dimensions, as identified from the interviews. E = Extrinsic Characteristics and I = Intrinsic Characteristics presented in Table 2.

User persona Characteristics	Corresponding Company Persona Dimension
Demographic dimension [15,58]	E1, E5, E6, I1, I2
Views, attitudes, and opinion [15,23]	E2, E3, E4, E7, I1, I5, I6
Emotions, fears, and aspirations [59]	E3, E7, I1, I7
Knowledge, skills, and capabilities [23,60]	E4, I5, I6, I7
Societal factors [35,55]	E5, E6, I1

5.1. Constructing Company Personas

Creating consensus among the stakeholders regarding the accuracy of the created persona is an identified challenge in design studies [59]. In order to overcome this, Miaskiewicz and Luxmoore [22] proposed a data-driven approach to creating personas and enhancing the organizational adoption of it. Adapting from this approach, we propose a four stage process of creating company personas:

1. Create an inventory of necessary sustainability attributes of the company.
2. Characterize the company based on the attributes along the 14 persona dimensions.
3. Incorporate additional inputs about the company through qualitative techniques such as interviews and action research.
4. Create the individual company personas by incorporating the initially identified attributes and input from Stage 3.

Applying this four stage process to the empirical data collected from the case companies, the authors observed certain overlap among the companies' attributes. Based on these inputs, we propose the following four personas to give readers an impression of a company persona as we envisage it.

Thus, as seen in user personas, the four stage process combined with the 14 identified dimensions could potentially develop company personas that highlight the niche characteristics of the company context from a DfS perspective. As can be observed from Table 5, such a description imbibes factors that were already widely discussed in literature as well as factors less addressed, such as risk sensitivity and the drive of the company.

Table 5. Persona samples extracted from case company interviews. Case companies matching the persona description are provided in parentheses. PD = Product Development, R&D = Research and Development, CE = Circular Economy, B2B = Business to Business.

Persona #	Persona Description
Persona 1 (Wood, Watt)	The company is a market leader in its industry branch with a high price and efficiency focused customer base. The company acknowledges the need for sustainability in its PD, however also identifies the indirect sustainability benefits from its product as a contribution to this. PD is very well formalized, nevertheless, DfS tools are not used consistently nor regularly. Certain customers request the company to provide environmental information that, along with other compliance requirements, are adhered to. Lack of both an exclusive sustainability department and market demand are two major challenges. The company aims at providing DfS solutions with increased efficiency and developing CE business models.
Persona 2 (Food, Soap, Vitamin)	A highly customer driven consumer goods company with sustainability conscious buyers and retailers. The company is quite early in its sustainability journey and has a great support from its senior management and marketing departments. There exists a lack of in-house resources such as DfS tools, clear definitions, and skill sets on sustainability. Being part of a corporate group, the company receives clear guidelines directing it. The smaller size of the company and market presence in certain categories makes it challenging to integrate sustainability along the value chain. The company aspires to be a market leader in sustainable alternatives compared to its larger competitors.
Persona 3 (Microbes)	The company has a long tradition of providing sustainability solutions to customers and operates in the B2B industry. Sustainability is strongly integrated in the senior management of the company and is involved in all PD stages. Stage gate models and DfS tools are used in a systematic manner in all projects. A lack of common understanding on sustainability is an identified challenge that leads to discussions. The company aims to integrate DfS focus in all management decisions and make it more visible in the near future.
Persona 4 (Pouch)	The company operates in a niche industry of vital and intimate support to customers, making utility, reliability, and quality of its products the biggest priorities. Therefore, the customers do not have a high sustainability demand. The company, however, realizes the impact of its activities and is committed to reducing the impact without comprising the utility of the product, which is often challenging. A lack of common awareness among the different departments on DfS is a big challenge in the company. Sustainability assessments are not regularized even though the company has the necessary skill sets. The company aims at consistent sustainability improvements in its products.

5.2. Implications of Company Persona Dimensions

The company persona dimensions can be seen as a mix of both the factual aspects [42] and the "soft-side" elements of the company [34,61]. While the former can be found in dimensions I3, I5, and

I6, the managerial conditions and other soft elements are mapped under the other 11 dimensions. As can be read from the cited quotations in Section 4, all 14 dimensions were found to have an influential role at one stage or another of DfS implementation in the case companies. These dimensions in totality help define a complete picture of the company's internal and external context, which have been otherwise less explicitly identified in company clustering studies. Furthermore, this also follows the embodiment feature of personas explained in Section 2.1, where the extrinsic characteristics define the external factors that influence the company while the intrinsic characteristics help the researchers and practitioners understand the company's internal functioning in the DfS context. Using such combinations in our case companies, we constructed the sample personas in Table 5 to reflect both extrinsic and intrinsic characteristics that may potentially influence the DfS context in the companies.

A general trend observed in both extrinsic and intrinsic characteristics was the stronger presence of certain dimensions in all of the case companies. While market conditions and the strategic focus of the company were the most important extrinsic characteristics observed, senior management approach, DfS implementation approach, and sustainability definition were found to be important among the intrinsic characteristics. This also follows findings by earlier DfS researchers who emphasized the need for the right market for eco-design products [31], the importance of management commitment [62], the need for sustainable strategies [32], and the level of formalization in eco-design processes [63], consequently pointing to the fact that the identified persona dimensions are in congruence to earlier empirical findings in DfS research. An example of including such a description in company personas is seen in sample Persona #1 (Table 4), where the buying patterns and customer needs vis-à-vis sustainability are discussed based on our insights from E4, E5, and E7. Importance of degree of formalization (I3) and its impact on the implementation process was found in almost all of the case companies interviewed. Persona #3 reflects on the presence of formalized processes in DfS implementation in terms of tools, stage gate models, and processes, which are also in line with the observations we made in *Microbes*.

Further, an interesting finding among the dimensions was the risk sensitivity approach of the companies, which could possibly help researchers and consultants understand the nature of the approach different companies prefer. Risk-averse companies tended to take a defensive approach to their business model, with a focus on compliance and adjustment in current models [39,64], while risk-taking companies were more proactive and would possibly restructure the whole business to accommodate DfS. Thus, practitioners and researchers helping a company can adapt their solutions in relation to the risk sensitivity of the company. In another observation, certain other dimensions were found to have strong interconnections among themselves. For example, sustainability understanding within the companies could be closely seen in connection with the strategic focus in the company and the way sustainability was prioritized within the company activities. Market conditions were often influenced by the history of the company, its strategy, and management decisions. Such interconnections are crucial to a company's context and should be factored in while providing recommendations.

Finally, as explained in Section 1, the eco-design tool usage was relatively low in companies when compared to the number of tools created for the purpose. Observations from the interviews supported this view; even though the need for tools was aired in the interviews, the skill set and adaptability of the tools to fit the company environment were more stressed. This again highlights the need for better understanding the company context in addition to the technical needs of DfS projects, and the potential value of our explorative study. A potential application of company personas in actual DfS implementation scenarios could be using this approach as a pre-requisite to applying tools developed to help companies in DfS implementation. The eco-design maturity model [8] is a well received management framework for companies involved in DfS projects, consisting of three main elements (eco-design practices, maturity levels, and application methods). The company persona definition can help practitioners enrich the understanding of the maturity levels of the company in terms of its managerial preparedness and aspirations, thereby complementing the integration of the

eco-design maturity model in practice. Another potential tool is the four-lens model for integrating sustainability in companies [57], which proposes a set of measures a company can take from four different perspectives—namely architect, catalyst, prophet, and advocate—to integrate sustainability in its activities. The company persona approach can help streamline the suggested course of action under each lens based on the niche characteristics of the company. However, the explorative nature of this paper warrants further empirical investigations in order to establish these potential usages in an industrial setting, as detailed in Section 5.3.

5.3. Limitations and Future Work

The number of interviews conducted for this study was 20 (including four interviews with sustainability experts). Among these, only one interview was conducted at Company B due to practical limitations. This disparity in the number of interviews provided a challenge in carrying out cross-comparative studies between different companies during the analysis phase. Additionally, one common criticism attributed to personas in design studies is the static nature of persona descriptions, which are not updated according to the changing needs of the user [65,66]. A similar challenge for company personas was also identified from the interview with SE1, where the respondent observed that companies do change their characteristics, if not rapidly, which necessitates a different approach to sustainability. A more in-depth study method such as action research in close collaboration with case companies is needed to accommodate such contextual changes of a company's persona. Further, more detailed field testing with both quantitative and qualitative data sets [58] is required to increase the robustness of the "company persona" as a practical aid in DfS implementation. Thus, future work will involve empirical testing and improving the identified company personas through workshops in companies and among researchers who have worked with DfS implementation in companies.

6. Conclusions

This explorative paper presented the "company persona" as an alternative approach to constructing an informed DfS implementation in companies. Our analysis of 20 semi-structured interviews with representatives from seven companies and sustainability experts (tabulated in Table 3) suggests that the complexity of factors that define a company's approach to DfS implementation can be represented by 14 dimensions, which together can be used to construct company personas. Such company personas thereby reflect typical combinations of extrinsic and intrinsic characteristics, as found in our case companies. We pose that using a "company persona"-based approach may fill a gap between generalist and individually customized approaches, and that companies would benefit from implementation approaches that help in understanding the context of the company in detail before proposing specific prescriptive measures [53]. Therefore, using the "company persona"-based approach has the potential to enable practitioners, academicians, and companies in making better informed decisions on the actual requirements of tools, guidelines, and consultancies companies that are required to deliver their stated sustainability goals.

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Appendix A

The interaction mapper used during the interviews.

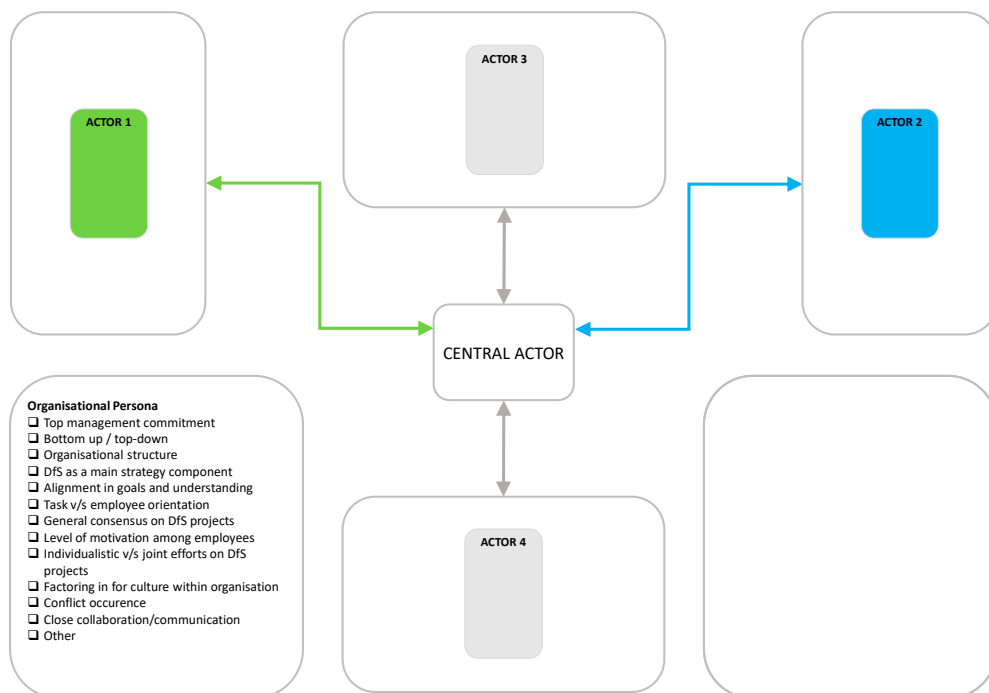


Figure A1. An illustration of the interaction mapper used during the interviews. The central actor was the interview respondent. The map was used to identify the various contextual elements of the company in relation to DfS implementation and different actors the respondent interacted with.

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PAPER V. FOUR LENS

- Authors:** Raphaëlle Stewart, Faheem Ali, Casper Boks and Niki Bey
- Full Title:** Architect, Catalyst, Advocate, and Prophet: A Four-Lens View of Companies to Support Ecodesign Integration
- Published in:** *Sustainability*, 2018
- Purpose:** To apply the four lens framework from general management literature to the context of eco-design integration and to prescribe measures that company management can take under each of the four lenses, namely, advocate, prophet, architect and catalyst.
- Method:** A literature review of studies that have used the four lens framework is carried out along with interviews with seven Norwegian and Danish companies involved in eco-design practices.
- Results:** A theoretical framework on possible measures relevant for eco-design integration under each of the four lenses is established based on review of extant literature on eco-design/DfS integration in companies and other empirical studies that applied four lens framework. Based on this and coding of the interview data, the paper proposes concrete measures on what measures eco-design proponents in companies can take to integrate sustainability measures from a management perspective.
- Contributions:** The relevance of the four lens framework from Bolman and Deal in eco-design integration is established, and the different lenses explored and measures listed. Further, the paper also discusses cross-lens effect between the four lenses and how it can address the contextual aspects of a company involved in DfS implementation.

Article

Architect, Catalyst, Advocate, and Prophet: A Four-Lens View of Companies to Support Ecodesign Integration

Raphaëlle Stewart ^{1,2,*} , Faheem Ali ^{1,2}, Casper Boks ² and Niki Bey ¹

¹ Division for Quantitative Sustainability Assessment, Department of Management Engineering, Technical University of Denmark, Diplomvej, Bygning 371, 2800 Kongens Lyngby, Denmark; faheem.ali@ntnu.no (F.A.); niki@dtu.dk (N.B.)

² Department of Design, Norwegian University of Science and Technology, Kolbjørn Hejes Vei 2b, 7491 Trondheim, Norway; casper.boks@ntnu.no

* Correspondence: rste@dtu.dk or raphaels@stud.ntnu.no; Tel.: +45-4525-1642

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Abstract: Companies are increasingly expected to develop products with better environmental performance throughout their life cycle. Academic literature on ecodesign integration, which investigates firms' practices of dealing with environmental concerns associated with their products, indicates a need for more focus on formal and informal organizational aspects. From the general management literature, the four-lens view of organizations provides a rich understanding of organizations by embracing their formal (structural lens) and informal (human, political and symbolic lenses) functioning. This article aims to explore the extent to which the four-lens view may support ecodesign integration in companies. This exploratory study builds on fifteen interviews about ecodesign integration at seven manufacturing companies in Denmark and Norway. The main results are threefold: (i) the different lenses of organizations could be found in measures mentioned at the case companies; (ii) measures from the architect's perspective seemed necessary to provide an official scene for ecodesign and help prioritizing it in organizations; and (iii) the catalyst's, advocate's, and prophet's perspectives seemed necessary to facilitate or complement the architect's perspective. In the light of these findings, the four-lens view seems relevant to strengthen ecodesign integration, and its potential use as a reflective tool is an avenue for future work.

Keywords: sustainability; ecodesign; product development; product innovation; change; organization; industry; case study; interview; Nordic

1. Introduction

As sustainability has become a central topic in our societies, companies are increasingly expected to tackle their environmental sustainability challenges. The product life cycle is a key perspective to address such challenges, as emphasized in academia and recent developments in industry, e.g., update of ISO 14001 environmental management system standard with greater emphasis on products' life cycle environmental impacts [1,2]. Ecodesign is a product-oriented approach defined as "a proactive management approach that integrates environmental considerations in product development and related processes (e.g., purchasing, marketing and research and development) [and] aims to improve environmental performance of products throughout their life cycle" [3]. The market of products labelled as environmentally superior has noticeably been thriving [4,5]. In the EU, regulations such as the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) regulation and the Restriction of Hazardous Substances (RoHS) directive, as well as the Energy related Products (ErP) and the Waste Electrical and Electronic Equipment (WEEE) directives, respectively require

the avoidance of substance of concerns (REACH and RoHS), energy efficiency measures (ErP) on e.g., home appliances and motors, and producer extended responsibility measures on electrical and electronic equipment (WEEE) [5]. Nevertheless, there is an urgent call for more radical changes in production and consumption patterns that would enable a transition towards sustainability as stated in UN Sustainable Development Goal 12 [6]. Our current understanding of environmental sustainability implies that environmental sustainability challenges ultimately need to be addressed at a socio-technical level [7]. Such endeavor requires companies, as a key stakeholder, to have a more comprehensive understanding and addressing of environmental concerns in the products and solutions they develop, e.g., by developing environmentally superior product/service systems or designing circular products and business models by intention [8,9]. However, empirical studies have shown that companies face challenges to develop and successfully implement proactive ecodesign practices [10–13].

Ecodesign tools, techniques and decision supports have been intensively developed in the past decades; e.g., Rousseaux et al. found more than 600 ecodesign tools in their literature review [14]. However, ecodesign scholars agree that these need to be complemented with a focus on business implementation and management problematics to help advance ecodesign uptake by industry [11,15–18]. In that perspective, scholars have explored how to formally integrate ecodesign aspects in business organizations, e.g., in project management [19–22], at different decision-making levels (operational, tactical and strategic—[18]), in environmental management systems [23], and in business procedures and strategy [11,24]. The ISO 14006 standard provides guidance for the implementation of ecodesign in companies as a management system [25,26]. On the other hand, scholars have highlighted that informal aspects of organizations also influence ecodesign integration in companies [11,17,18,27–29]. Hence, we identify a need for approaches embracing both aspects, i.e., the combination of formal aspects (“structures, processes, systems, etc. which are designed to motivate and facilitate individuals in the performance of organizational tasks” [30] (p. 193)), and informal aspects (“patterns of communication, power, and influences, values and norms which characterize how an organization actually functions” [30] (p. 193)).

In management literature, Bolman and Deal elaborated a four-lens view of organizations which builds on four groups of management theories depicting organizational functioning from different perspectives [31]. In this four-lens view, organizations are viewed on the one hand as formal structures designed to fulfill a given mission, applying specific procedures, systems, and roles (structural lens). On the other hand, firms are informal communities where employees have needs, aspirations, preferences and fears (human lens), personal or group agendas with possibly conflicting objectives (political lens), as well as a shared understanding of “how things work around here” (e.g., habits and routines) (symbolic lens) [31]. The four-lens view underlines that single situations in organizations can be looked at, interpreted, and leveraged from different perspectives offered by the different lenses. In that sense, the four-lens view invites leaders and change agents in organizations to reframe their views of their organization to better understand situations and adopt relevant courses of action.

Within internal stakeholders driving sustainability in organizations, we can distinguish between employees primarily working with environmental management, e.g., a sustainability manager or Environment, Health and Safety specialist, and employees working in core business roles who seek to drive the sustainability agenda based on individual interest [32]. These two types of stakeholders have been found to be central in driving sustainability practices in companies [33–36], and have been expected to drive sustainability integration in their organization as “champions”, “change agents” or “leaders” [32,35–39].

Because it provides a framework to approach the richness of organizational functioning with a focus on both formal and informal aspects, and because it may deliver practical support for change agents in organizations, the present study draws on the four-lens view of organizations and aims to answer the following research question: *To what extent can the four-lens view of organizations support ecodesign integration at companies?* To address this question, first we build on existing academic

literature to identify the potential relevance of the four-lens view of organizations in the light of common challenges associated with ecodesign integration. Furthermore, we empirically investigate the presence of and relations between the different lenses of organizations in ecodesign integration efforts in industry, with the purpose to further our understanding of a multi-lens approach.

Ecodesign proponents in companies, including both sustainability or environmental management teams and employees from core functions proactively involved in pushing the ecodesign agenda within their organization, are the target audience of our study, together with consultants and scholars working with supporting ecodesign integration in companies. In the remainder of the article, we first elaborate the conceptual framework and link the four-lens view of organizations to existing knowledge of ecodesign integration in academic literature (Section 2). Then we investigate how the four-lens view emerges from ecodesign integration as described in interviews conducted at a set of case companies: Section 3 explains how the empirical evidence was collected and analyzed; the results are presented in Section 4. In Section 5, the findings are discussed in the perspective of earlier work, the research design, and the limitations of the study, before providing concluding remarks and an outlook for future work in Section 6.

2. Conceptual Framework

2.1. Introducing the Four-Lens View of Organizations

Bolman and Deal's four-lens view of organizations was developed with the aim to bring together different groups of management theories to pragmatically support the work of managers and change agents in organizations [31]. The structural lens (or frame) builds among others on Taylor's scientific management theory [40], Weber's bureaucratic management theory [41], and Mintzberg's work on organizational structures [42]. The human lens is derived among others from the Theory Y (as opposed to Theory X) developed by McGregor [43], and the work of Argyris on the relationships between organizations and individuals [44]. The political lens is anchored among others in the work of Kotter and Pfeffer about political skills of managers [45,46]. The symbolic lens draws among others from the work of Schein on organizational culture [47]. The structural lens emphasizes division and coordination of work and embraces well defined rules, policies and goals; the human lens focuses on the relationships between employees and the organization and pays specific attention to individual needs; the political lens views organizations as arenas where stakeholders compete for power and resources; and the symbolic lens focuses on creating meaning in a chaotic environment [48].

The purpose of the four-lens view is to invite leaders and change agents in organizations to reframe, and hence expand, their views of their organization to gain a deeper understanding of hotspots or challenges and a better overview of available levers. This is done by alternatively using an architect's, catalyst's, advocate's, or prophet's perspective corresponding to different metaphors of organizations. Through the structural lens, the architect views its organization as a machine or a factory and design targets, functions, processes, and coordination mechanisms. Through the human lens, the catalyst views its organization as a family and aims at embracing employees' needs, fears and aspirations and supporting them. Through the political lens, the advocate views its organization as a jungle and aims at building coalitions, gaining power, and negotiating agendas. Through the symbolic lens, the prophet views its organization as a temple and focuses on fostering sense-making, challenging common beliefs and inspiring people. Figure 1 displays the four-lens view of organizations as a conceptual framework which includes for each lens (i) the corresponding metaphor of organization, (ii) the perspective adopted by change agents, (iii) the summary of associated basic assumptions about organizations, and (iv) examples of courses of action, adapted from the work by Bolman and Deal [31,48].



LENS	STRUCTURAL	HUMAN	POLITICAL	SYMBOLIC
METAPHOR OF ORGANIZATION	FACTORY OR MACHINE	FAMILY	JUNGLE	TEMPLE
PERSPECTIVE ADOPTED BY THE CHANGE AGENT	ARCHITECT	CATALYST	ADVOCATE	PROPHET
SUMMARY OF BASIC ASSUMPTIONS	<ul style="list-style-type: none"> The organization exists to achieve established goals and objectives. What matters is that tasks are clearly and rationally divided, defined by procedures and coordinated so that work gets done. 	<ul style="list-style-type: none"> People and organizations need each other: organizations need ideas, energy, and talent; people need careers, salaries, and opportunities. What matters is to align people's needs and aspirations with the organization's goals. 	<ul style="list-style-type: none"> The organization is an arena where individuals and interest groups fight over resources to advance their agendas. What matters is to gain power, create strong alliances and manage to secure resources and priority in agendas. 	<ul style="list-style-type: none"> Organizations are chaotic, uncertain and ambiguous places where much is open to interpretation. What matters is to create meaning and to understand deeply anchored aspects ruling in the organization.
EXAMPLES OF COURSES OF ACTION	<ul style="list-style-type: none"> Reorganize, implement or clarify policies and procedures Develop new information, budgeting, or control systems Add new organizational units Plan processes 	<ul style="list-style-type: none"> Processes of participation and involvement (task forces, open meetings, etc.) Empower Address individual needs, personal aspirations 	<ul style="list-style-type: none"> Bargain Negotiate Advocate Build alliances Network with other key players Anticipate conflicts 	<ul style="list-style-type: none"> Create or revitalize ceremonies and rituals Work to develop or restate the institution's vision Use heroes, stories, symbols Energize, inspire

Figure 1. Conceptual framework around the four-lens view of organization, including for each lens (i) the corresponding metaphor of organizations, (ii) the perspective adopted by change agents, (iii) the summary of basic assumptions about organizations, and (iv) examples of associated courses of action, elaborated based on the work by Bolman and Deal [31,48]. Icons from left to right: Architect by Augusto Zamperlini from Noun Project; Family by Luis Prado from Noun Project; Lawyer asking question by Gan Khoon Lay from Noun Project; Hero by Andrew J. Young from Noun Project.

Organizational research scholars have used the four-lens view as a main conceptual framework in empirical studies focusing on four distinct topics. They have investigated (i) change management [49–51], (ii) current organizational situations [52–54], (iii) specific roles or positions [55], and (iv) lens preferences of leaders and managers [48,56–58]. Applicative studies have focused primarily on educational organizations [48–50,58], and to some extent on healthcare organizations [50,56,57]. In the first group of studies, the four-lens view has been used to interpret challenges associated with the investigated change, e.g., innovation in higher education [49], implementation of a participatory management approach in a hospital [51] or academic reform in pharmacy [50]. Scholars agreed that using a multi-frame approach enabled deeper understanding of situations and should be used to design relevant solutions and improvements [49–51]. In the second and third group of studies, the model has been used to interpret current challenges, experienced in general in the organization [52,53] or by specific individuals [55]. It was also used to interpret the success factors of a given program [54]. In the last group of studies, the model has been used to explore the use of lenses by managers and leaders in organizations, as well as to study the influence of lenses' use on managerial and leadership effectiveness. For instance, Bolman and Deal used their model to study the extent to which managers, mainly in academic institutions, used different lenses in their approaches, based on analyses of critical incident reports, and how it affected their effectiveness as managers or leaders as perceived by their colleagues, based on a survey [48]. In the analysis

of critical incident reports, they found that the structural frame was particularly prominent among managers and the symbolic frame, particularly absent. To survey the lenses currently used by managers in their work, Bolman and Deal developed a leadership orientation instrument operationalizing each lens into a set of activities or attitudes [48]. The survey revealed that effective managers were associated with the structural lens, whereas effective leaders were associated with the political and symbolic lenses. The leadership orientation instrument was further used by several scholars for a similar purpose [56–58]. In the context of schools and universities, Thomson found that fully balanced managers, i.e., managers who scored high on all lenses, performed better on all leadership dimensions, than unbalanced managers, i.e., mainly using one or two lenses [58]. In their study of health information program directors, Sasnett and Ross found that the structural and the human frames dominated, to the detriment of the political and symbolic frames [56]. McGowan and Stokes surveyed a sample of Irish physiotherapy managers and also found that the political and symbolic lenses were underused, whereas the structural and human lenses highly used [57]. They further found a correlation between the number of lenses reported as used by managers and higher self-rating of effectiveness as leaders and managers [57].

2.2. The Four-Lens View of Organizations in the Context of Ecodesign Integration

Earlier scholars have considered ecodesign integration as an organizational change and built on the change management literature to investigate the phenomenon [28,59]. Ecodesign proponents are expected to play the role of leaders or change agents in their organization. In these perspectives, transposing the four-lens view of organizations to the context of ecodesign integration appears as a meaningful potential approach to support ecodesign proponents in their efforts to strengthen ecodesign integration. Furthermore, the academic literature on ecodesign integration has reported several internal challenges which can interestingly be shown to pertain to the four lenses of organizations as described in the following paragraphs [60].

Through the structural lens, scholars have reported the lack of strategy or concrete goals to integrate environmental aspects in products [17,61–63], the absence of a predefined toolset to support ecodesign decision-making, and the lack of formal presence of ecodesign aspects in project assessment frameworks [19,22], and performance measurement systems [61,63]. Additionally, scholars reported lack of clear responsibility allocation and presence in the organization [17,39], and the absence of specific mechanisms to collect information related to sustainability from the market and regulation [62]. Scholars have recommended exploring possibilities to integrate ecodesign aspects in existing processes [11,12,19,21,64–66], in order to create an official arena for discussing environmental aspects [65], and investigating how to formally integrate ecodesign aspects in the different levels of organization, i.e., operational, tactical and strategic [18]. The establishment of clear environmental goals for product design is also recommended, as well as the creation of environmental specialist roles to support development processes [39,64,66].

Through the human lens, earlier studies have shed light on the fact that employees in companies may fear work overload associated with ecodesign [28,61], as well as losing flexibility [28]. Some employees may also be highly uncomfortable with the topic [13,28], not aware of the challenges [67], or not capable of addressing them [12,28,64,67,68]. Some employees may have high interest, motivation and commitment for ecodesign aspects while others lack one or the three [12,64]. Exploring how to best empower employees on sustainability topics and what drives motivation and resistance of/among employees has been suggested as a key enabler to support ecodesign integration [13,69].

Moving on to the political lens, scholars have reported that environmental sustainability aspects may have rather low priority on senior management agendas which mainly focus on short term objectives, mainly lowering costs, and do not see environmental concerns as major risks since market and regulation drive is perceived as low [13,62,68]. It has also been indicated that project teams may struggle to secure resources for ecodesign activities [13], or translate environmental information into

information useful for the business and possible to integrate in a business case that senior management could be interested in [12,62]. Maintaining consistent support from management for ecodesign aspects over time is also a reported challenge [13,16]. Because people have different agendas and areas of interest, due to their position in the company, they may value information differently. Hence, concretely it may be the case that employees observe some trends regarding environmental sustainability concerns of customers but do not pass them on further in the organizations [70]. In response, it has been recommended for instance to review key performance indicators of the people who need to be convinced for environmentally preferable solutions to be pushed for, and to adapt communication strategies accordingly [71].

Finally, through the symbolic lens, earlier studies have reported resistance to ecodesign integration pertaining to general beliefs such as “sustainability is not my responsibility”, “sustainability is not invented here” [28], “sustainability is a distraction” [61], or “sustainable options lead to costly or poor quality products” [13]. Common understanding around what sustainability means for the business may be lacking [72]. The needs for a new “mindset emphasizing the importance of the environmental considerations” [64] (p. 103), or for a different “storytelling” around environmental aspects closer to the company’s reality have been evoked [13]. Skelton et al. reported that although environmental specialists are listened to by project teams, they may remain considered by the latter as very much outside the project community which limits their influence on projects [29]. The use of rituals, e.g., a dismantling event taking place every year to build awareness about the end-of-life of developed products [29], may be leveraged through the symbolic lens.

Hence, existing knowledge of ecodesign integration indicates the potential relevance of the four-lens view of organizations to support ecodesign proponents in their efforts to strengthen ecodesign integration in their company. The following sections explore how the four-lens view can be addressed in a consistent manner and further translated into the ecodesign integration context with learnings from empirical data.

3. Methodology

An overview of the methodological approach adopted in this study is displayed in Figure 2. The following sections provide detailed descriptions of data collection and data analysis.

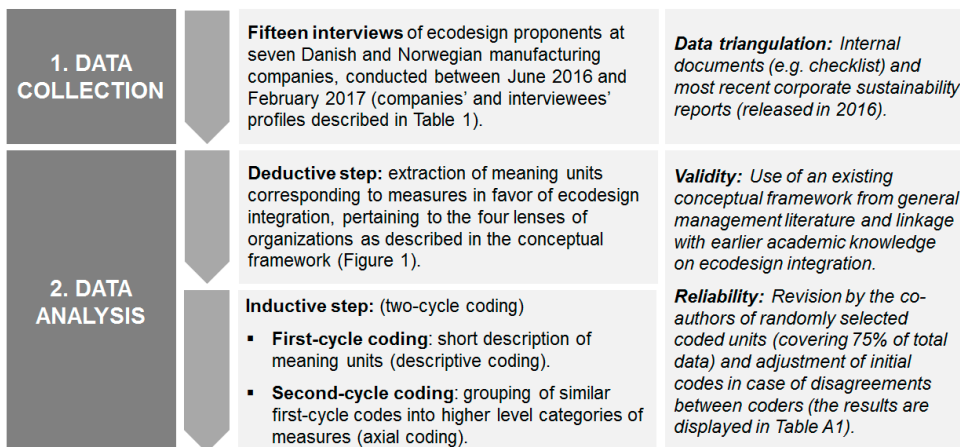


Figure 2. Overview of the methodological approach.

3.1. Data Collection

The empirical basis of the present study consists of a set of fifteen interviews at a sample of seven case companies in the Danish and Norwegian manufacturing sector. There is no specifically recommended number of cases in case study research, but four to ten cases are typically targeted [73]. Earlier empirical studies of ecodesign integration in companies have typically included four to twelve case companies and most studies have involved two or three interviewees per case company [12,13,27,62,63,66,67,74–76]. Manufacturing companies were of particular interest for the present study because they are key players in designing and manufacturing products [77]. Moreover, there are indications that the manufacturing sector has a stronger focus on life cycle thinking than the service sector [78,79]. The selection of case companies is based on convenient sampling, i.e., based on previous or new established contact with companies, and on a set of criteria, namely (i) headquartered in the Nordics, (ii) manufacturing companies with in-house product development, and (iii) presence of a sustainability strategy. The case companies are large organizations, with all but one (which is not stock exchange listed) included in the Dow Jones Sustainability Index (DJSI). From this perspective, the set of cases presents characteristics of homogenous sampling, but also characteristics of variation sampling because the case companies were at different steps of their sustainability journey and belong to different industrial sectors [80].

Lasting between 60 and 90 min, two authors of the present article conducted the fifteen interviews between June 2016 and February 2017. The details about the interviewees' profiles are displayed in Table 1. The set of interviewees includes two types of ecodesign proponents. The first type includes employees working in sustainability-related functions, e.g., sustainability managers or Environment, Health and Safety specialists, and the second type includes employees involved in product development with personal interest in pushing the ecodesign agenda. Interviews were semi-structured and designed to further the knowledge about ecodesign integration in companies, based on a review of existing academic knowledge of the topic. The interview focus was on (i) investigating how ecodesign practices have been and are being integrated in the organization and (ii) exploring internal (across departments) and external (in the business ecosystem, e.g., with suppliers and customers) interactions around ecodesign at the company. The themes addressed during interviews are provided in Appendix A. In the present study, the interview transcripts are thus used as a secondary data source to explore the presence of the different lenses of organizations in ecodesign proponents' elaborations about ecodesign integration at their company.

Internal documentation provided by the case companies (e.g., stage gate model used by the company in product development projects, ecodesign checklist and ecodesign tool) and their most recent corporate sustainability report (released in 2016) were used as complementary data source and enabled some extents of data triangulation. Corporate sustainability reports were particularly suited to grasp the overall sustainability context at each case company and in order to elicit companies' sustainability vision, drivers (e.g., presence of a market for ecodesigned products), strategy (e.g., reducing the life cycle environmental impacts of products) and targets (e.g., reducing greenhouse gas emissions in the product portfolio, reaching a certain percentage of recycled material in packaging and phasing out substances of concern), in relation to the architect's perspective. However, corporate sustainability reports provide poor inputs on other organizational aspects associated with sustainability integration [81].

Table 1. Interviewed case companies, sectors of activity, number of interviews conducted and interviewees' job area. EHS = Environment, Health and Safety; CR = Corporate Responsibility; R&D = Research and Development.

Company	Sector	Number of Interviews	Interviewees' Job Area
Company A	Medicare	2	A1: EHS A2: EHS
Company B	Biotechnologies	1 *	B1: Sustainability
Company C	Energy	2	C1: EHS C2: EHS
Company D	Construction	2	D1: Regulation (incl. environment) D2: Sourcing and technologies
Company E	Consumer products	2	E1: EHS E2: CR
Company F	Consumer products	2	F1: Communication F2: Sourcing
Company G	Consumer products	4	G1: R&D G2: R&D G3: R&D G4: Marketing

* Information about ecodesign activities collected at a university lecture given the same year by another sustainability expert of the same company was also included in the analysis.

3.2. Data Analysis

The unit of analysis, defined as the phenomenon under study [82], is ecodesign integration at each case company, including all activities which aim at bringing environmental considerations in the company's products. To address the research question, we analyzed the interview data with the two following objectives: (i) exploring the presence of the different lenses of organizations in descriptions about ecodesign integration at the case companies, and (ii) gathering indications of relations between the different lenses of organizations.

To explore the presence of the different lenses, we analyzed each interview transcript using a deductive-inductive content analysis method [83]. The deductive step consisted of identifying "meaning units" (or coded units) corresponding to measures stemming from the different lenses of organizations. Meaning units are defined as "words, sentences or paragraphs containing aspects related to each other through their content and context" [84]. In our case, sentences or paragraphs were manually unitized from the transcripts as meaning units based on thorough reading of interview transcripts. An example of meaning unit is the following extract "Stage gate is the normal process. And life cycle assessment is part of the stage gate project. And we use the stage gate model in development projects, for all new products actually". A "measure" was broadly defined as an action or solution indicated by the interviewees as happening or necessary to facilitate ecodesign integration. The deductive coding of meaning units with respect to the four lenses of organizations was based on the conceptual framework derived in Section 2, see Figure 1. The meaning units were stored in a spreadsheet for the second (inductive) step of the analysis. In the inductive step, we coded the extracted meaning units, using a two-cycle coding approach, as suggested by Saldaña [85]. The first-cycle coding phase consisted of descriptive coding, i.e., associating each meaning unit with a short phrase summarizing the described measure [85]. For the example of meaning unit mentioned above, the first-cycle code we chose is "Life cycle assessment is used as part of the product development process". The second-cycle coding phase consisted of grouping the first-cycle codes into higher-level categories of measures using an axial coding approach, i.e., seeking to group together codes that had been split in the first-cycle coding but were then considered to reflect similar aspects [85]. For the example of meaning unit mentioned above, the second-cycle code we chose is "Integrate ecodesign procedure in product development

process". To explore the relations between the different lenses of organizations in supporting ecodesign integration, instances where they could be found to interact with each other were analyzed.

To ensure the quality of the analysis, we followed the guidelines provided by Riege [86]. Validity was enhanced by anchoring the findings in a conceptual framework derived from management literature and comparing the results with insights from the ecodesign integration literature. The use of the four-lens view to conduct content analysis was found challenging by Bajis et al. who reported initial overlaps between each lens [50]. This aspect pertains to the reliability criterion and was addressed in the present study through the recording and transcribing of the interviews and through involving multiple researchers in the data analysis [86]. The full coding process was initially performed by one author (the main coder). Seventy-five percent of the coded units were randomly selected for a revision by the co-authors. The selection was designed to respect the proportions of coded units for each case company, e.g., a total number of 100 coded units for one case company would lead to 75 randomly selected coded units for the revision. The selected coded units were then divided into three parts and checked by the co-authors against (i) the lens of organization the coded unit was considered to relate to, and (ii) the choice of second-cycle coding. The division was done so that one co-author would review the full set of selected coded units corresponding to a given case company, to build an overview of that case company. The revision and associated discussion led to slight changes in the coding results (see Table A1 in Appendix B) and wording chosen for second-cycle codes. The most challenging part of the coding was the deductive phase consisting of associating measures for ecodesign integration to an underlying lens of organization. The team agreed that to conduct such exercise, the coder should rely on the basic assumptions of what an organization is, as displayed in Figure 1, which are implicitly present in the interviewee's explanation. Illustrative quotes inserted in the following sections are extracted from the interview transcripts. They were corrected for grammar errors, false starts and filler words, as well as neutralized, e.g., by removing references to country markets or specific materials, so that neither the case companies nor the interviewees could be recognized [87].

4. Results

4.1. Mapping of Measures for Ecodesign Integration in the Four-Lens View

Table 2 shows for each case company and lens of organizations the identified measures resulting from the second-cycle coding phase. The distribution of coded units in the different perspectives of organizations is shown in Table A2 and examples of first-cycle coding phrases associated with second-cycle coding categories are given in Table A3. We make a difference between the measures indicated as currently happening at least to some extent in the company (i.e., established for the architect's perspective or leveraged approaches for catalyst's, advocate's, or prophet's perspectives), and the measures identified as lacking and needed. However, the distinction is not in focus in the present study which concentrates on measures as levers for ecodesign integration, rather than measures being practiced. Our findings indicate that for most case companies, measures stemming from the architect's, catalyst's, advocate's, and prophet's perspectives were present in discussions about facilitating ecodesign integration within the organization. Most frequent measures (both happening and lacking ones) across case companies include "integrate ecodesign procedure in product development process", "acquire/develop tools for decision-making", "design strategy related to products" and "set direction/target/goals" (architect's perspective); "support/chaperon initiatives" (catalyst's perspective); "align with business/stakeholders' agenda", and "negotiate for prioritization" (advocate's perspective); and "manage beliefs/"truths" in the company" (prophet's perspective).

Table 2. Results from the second-cycle coding. For each lens, mentioned measures in favor of ecodesign integration are mapped against the case companies. H = indicated as happening at least to some extent in the organization; N = indicated as lacking and needed.

MEASURES	Company A	Company B	Company C	Company D	Company E	Company F	Company G	No of Companies
Architect's perspective								
Integrate ecodesign procedure in product development process	H	H	H	H	N	N	N	7
Acquire/develop tools for decision-making	H	H	H	H	H		H	6
Design strategy related to products		H	H	N	N		N	5
Set directions/goals/targets		H		N	N	N	N	5
Develop guidelines related to product development					H	H		2
Formally define "sustainability" (e.g., standard, criteria)				H		N		2
Translate strategy into action plan for specific business units/functions					H		N	2
Translate corporate targets into targets for individual innovation projects		N						1
Create sustainability roles				H				1
Set up new KPIs					H			1
Use a process with more experimental approach							H	1
Catalyst's perspective								
Support/chaperon initiatives	H		H	H	H			4
Increase comfort of people to work with the topic of ecodesign		N	H		H			3
Build individual awareness of impact of decisions	H			N				2
Leverage people's aspirations	H		H					2
Participative approach to adapt the product development process		H	H					2
Frame ecodesign challenges in familiar terms			H					1
Give autonomy					H			1
Trigger people/"plant seeds"	H							1
Advocate's perspective								
Align with business/stakeholders' agenda	H	H	H		H	H	N	6
Negotiate prioritization of ecodesign in agendas	N			H	H		N	4
Emphasize criticality/emergency for business	N			H	H			3
Target efforts/"pick battles"	H	H					H	3
Ally with/get support from relevant people in the company	N					H		2
Have answers to all technical questions			H	H				2
Leverage network in the company			H		H			2
Secure present resource allocation for long term/more prospective objectives	N						N	2
Leverage existing umbrella projects			H					1
Prophet's perspective								
Manage beliefs/"truths" in the company	H		H	H			N	4
Change perceived vision/mission of the company				N			N	2
Leverage "typical ways of doing"	H			H				2
Preach in the company	H			H				2
Provide inspiration from outside						H	H	2

4.2. The Architect's Perspective

Within the sample of case companies, some had rather formalized integration of environmental aspects in product development through e.g., the systematic conduction of environmental assessments, whereas others had lesser formal integration in their product development processes. In all case companies, the role of formal integration of environmental aspects in product development processes or strategy in facilitating ecodesign integration was emphasized. At Company A, formal integration is established through the systematic conduction by environmental specialists of a life cycle assessment (LCA) summarized in a brief report using simple color coding to support each product development

project. There, the latter measure was described as an enabler for ecodesign integration, because it makes it normal to look at environmental criteria in product development.

“And, they listen and they use it also as a part of their decision. They may not do it as I recommend, but that is also because there are so many other criteria for the new product they look into. But they do listen and look into my inputs. [. . .] it is closely embedded in each stage. They cannot just skip it, if they think it is not relevant.” (Interviewee A2)

At Company B, the presence of a top-down strategy for developing sustainable products was presented as an enabler for ecodesign integration, because it leads to higher prioritization in agendas.

“If it is not top-down, it is really hard. It is really hard to go bottom up, I can tell you from experience. Of course you can try to push in the doors, but without management commitment . . . [. . .] So, if you are not being told that this is your target and this is your agenda, you need to make sure that you develop some sustainable product or you engage customer on these topics, you won't prioritize it.” (Interviewee B1)

The case companies where formal integration of environmental aspects in product development processes was described as lacking, or only partly in place, indicated that more formal integration was necessary to support ecodesign. At Company D, LCA models were indicated to be available for all products but a lack of systematic use by project teams was mentioned, and more emphasis on using such tools in product development projects was suggested as a way forward. Furthermore, the interviewee indicated a current effort in the organization to design a tool to assess material environmental sustainability performance to establish a currently missing common language around sustainability. At Company E, F and G, the need to formally integrate environmental aspects in processes and systems was highlighted by most interviewees. Interviewees E1 and F1 highlighted the need for guidelines to channel efforts in the organization.

“I think, it's working okay so far and towards the targets we have set, I think it's working okay. But if we want to take a larger step, it should probably be more guidelines and support from central to be able to take a larger step.” (Interviewee E1)

“What we want to do is a sort of 4–5 guidelines that you should always consider in an innovation process or communication or other things, you always consider that. [. . .] So it has been more ad hoc in the way we have introduced these subjects, but what I really believe in is that we have to write a lot of these. You don't succeed in doing it, if you don't have it as part of the structure. What kind of questions should you ask when you [approach] this kind of product? Yes, you should ask these, these and these questions and those sustainable questions [. . .] And I think that natural or routine guidelines on that level are important, if not, it is more accidental. [. . .] So again, I believe more in guidelines and structure. Otherwise, it is going to be, like I think this is a good idea and this one is a good idea etc. But I think it should be part of the whole structure.” (Interviewee F1)

Interviewee G2 emphasized the need for a strategic approach and dedicated budget so that solutions can be developed by teams to achieve tangible goals.

“I think that it is number one to have a good strategic approach to it and handle sustainability in the way you would handle other elements of your business. Plan for it, give it a budget, not an economic budget, but a sustainable budget saying that we need to reduce this and this. And then track it. So it is easy for us also to promote good solutions, because then you have a reason when you launch something that is recyclable, then you reduce the footprint. This then, you can use in your work in achieving the strategic goals. So I think we are in a little slow or this is very early for us to be . . . so we need hopefully to have more of this.” (Interviewee G2)

Interviewee G1 argued that specific ecodesign tools should be included systematically in all innovation projects.

“We need to be much clearer on what we mean in our innovation work, how we take it in on board or what kind of tools we need to implement in our projects. It should not be a question about if it is a sustainable or ecodesign project. It should be included into every single project.” (Interviewee G1)

The need for solutions from the architect’s perspective was put forth by one interviewee at Company G when describing a measure stemming from the advocate’s perspective, namely identifying low-hanging fruit, and suggesting targeted actions to reduce the carbon footprint of a set of products, because the latter was considered tedious without the support of architect’s measures.

“I had the initiative to develop CO₂ calculations for 8 case projects to try to figure or to map out which elements with the products have the biggest influence, which projects have the lowest hanging fruits you can tackle. And that was an initiative that was not from the management, so it was tough for us, because you needed to have sustainability anchored or embedded with the management team. Or else you will have hard time to getting it through the system, getting the funds and things like that. So, this was an initiative which I hope would give a lot of options further down the road.” (Interviewee G2)

At Company C, there was an ongoing discussion about integrating LCA as a tool in the product development process, the latter being expected to create an entry point for product developers to get closer to LCAs.

“That is where we are in the process of making an official process for the LCA and then the hope is that traditionally, when we have a new procedure, you have a group of people that review the document and then it is associated with an implementation plan. And the goal of this will be to . . . Actually, in our EHS plans, we have traditionally EHS reviewers, and the goal with the LCA procedure is not to have actually EHS reviewers but to have reviewers from the product development and the sales functions. And that will be to somehow act as an introduction and then we will take some communications” (Interviewee C1)

Interestingly, setting environmental targets for products was mentioned as a non-taken measure at Company A and Company C. At Company A, the reported foremost priority of the company is to provide solutions to people who need medical support in their daily life and environment-friendly solutions are weakly driven by the market. Hence, improving the environmental performance of new product generations was considered as a nice-to-have but could not be set as a must in projects. At Company C, the interviewees indicated that material and energy efficiency gains from one generation of products to the other were inherently driven by the business and thus no target was defined from an ecodesign perspective. At Company D, one interviewee also highlighted this idea that energy efficiency was core to the business activity, but that targets regarding material recyclability should be developed. Another interviewee at Company D indicated that there was a lack of direction or focus from top management when it comes to taking decisions in favor of material sustainability, which she explained by a lack of pull from the construction market for “green stamped” products.

4.3. The Catalyst’s Perspective

Interviewees at Company B and Company C indicated that the formal establishment of ecodesign aspects in the product development process (architect’s perspective) had been designed with the participation of stakeholders from product development, which pertains to the catalyst’s perspective.

“We developed this procedure and instruction and before then going on into a second review, we brought it into the project management and engineering functions and we sat in workshops with them, trying and testing it out, piloting it and just talking about it, making sense about it to see if it really fits because it was having to align with another process.” (Interviewee C1)

At Company A, when commenting on the extent to which environmental criteria were looked at and taken into account by project teams, one interviewee indicated the high dependence on employees’

(project managers or specialists) own aspirations to push for the ecodesign agenda in projects and hence the importance to assure that employees who are eager to drive the change can be supported. Such observations can be associated with a catalyst's perspective. The importance of identifying and building on employees' aspirations for ecodesign was also indicated at Company C.

"It always comes down to the passion of the project manager or the specialist, when it comes to this area, environment, responsibility in general, yes for sure. So that's a huge difference between one that thinks "this is very important to me", then they will really take care of it and try to get it into the project as long as they can drive it, as far as they can drive it you could say; while others would be more reluctant saying "this is not something that's on my list". [. . .] what we can do is that we can support the ones that really want to make a difference here, to give them good evidence so they can go and argue." (Interviewee A1)

"And I would also argue, beyond just personal relations it might also be the personal ambitions or the flexibility of the people you approach. Because you could possibly have someone in your personal network that maybe isn't as ambitious or burning about the topic, in that sense. And I just think also the person in this position was also aligned with somehow same interest and excitement in circular economy topics and was aware of that, whereas somebody else wouldn't have been as willing to drive it. I think." (Interviewee C1)

At Company B, the interviewee outlined that increasing the comfort of employees related to using environmental information was key and sought to be achieved through producing "digestible" material but that more training might be necessary to foster higher levels of comfort.

"LCA is a very scientific tool. We try very much to make it easy to communicate, by preparing slideshows and other materials for them that is easy to digest. And maybe what we are lacking is this training to make them comfortable, because level of comfort depends on person to person, whether they are comfortable in bringing the messages that we could give them." (Interviewee B1)

At Company C, one interviewee mentioned that efforts from a catalyst' perspective were deployed to frame environmental challenges into technical problems for engineers, who are very familiar and good at solving this type of problems, to be empowered and work on solutions.

"So I think the technical engineers are really good at doing a lot of stuff, especially if they know where to end, they are good at solving those problems. So I think if you could remove the fuzzy front end and standardize the work flow, say: "I have a [certain type of material] which wastes production and I don't want that", "I can solve that problem". So, at least that is what we are talking about now, trying to set up something where we can reach larger audience from technical side to have these ideas implemented." (Interviewee C2)

4.4. The Advocate's Perspective

The advocate's perspective could be identified in different measures for instance regarding deploying targeted efforts (i.e., "picking battles") (e.g., at Company B), emphasizing criticality for the business (e.g., at Company D) and aligning with business/stakeholders' agenda (e.g., at Company G).

"I think we are having the approach, instead of approaching the marketing in general, that we pick out some areas that we focus on. So we try to pick out some specific projects and deep dive into these from a sustainability point of view and leave the rest. So that has been our approach, also to show what we can bring to the table." (Interviewee B1)

"We had a pilot case running in [a certain market country] during the analysis so we were working very closely with them on [circular economy]. And they are one of our main markets in Europe, so also an important market. And that made management listen better. Because it was not, I mean, [the home] market is important to us, but it is a very small market compared to the rest of Europe. So, if

something happens in [the home market], I think we will survive. But, if something happens in [the other market country], we have to react because it will influence the company.” (Interviewee D1)

“I don’t have all the knowledge to convince them why this is so correct. So, it is . . . knowledge about sustainability and why it is good for your business. I mean why it is good for environment is easy to say. But why is it good for your business. How it can help to increase the profits, for example.” (Interviewee G4)

Although environmental aspects were mentioned to be integrated in their product development through the systematic use of an ecodesign procedure as part of the process, Company A had experienced so far rather low demand from the market and regulations in terms of ecodesign. No target for product environmental performance is in place in the company, beyond the “rule of thumb” to decrease impacts from one generation of product to the other. It was mentioned that product development teams need for off-the-shelf materials to be used in projects and that the latter must meet very high property requirements. Environmentally preferable materials may not be mature enough to meet these criteria. One interviewee mentioned the need to have senior managers understand environment-related risks for the business in the future and secure resources to conduct research and development activities around new materials that can be both environmentally preferable and meet the high property requirements.

“The big challenge is that there will be an increased demand for sustainability and the challenge is then to find sustainable materials that fulfill the requirements that we have. Because we have so many really specific high demands for the materials, that they are [with a certain product characteristic] and so on. So that’s a challenge. And that’s where I think some innovation projects could help on that. Because it’s not a shelf product we are looking for here we need to develop some new . . . [. . .] I think it is more on prioritizing resources for innovation of sustainable materials” (Interviewee A2)

Another example of an advocate’s perspective at Company A was associated with the idea of engaging people who are trusted and listened to when it comes to product development topics, to speak up for environmentally preferable solutions. The idea of allying with relevant people in the organization was also indicated at Company F.

“So that’s what you need from these guys is that, if we stand up and tell something it would be “yeah okay but you are also the environmental guys, you don’t know anything of the business case and you are the tree lovers”, more or less, right? Whereas if it is the marketing person saying: “we see this and this and this and by the way we also think from an environmental point of view that we could do like that”, then it is more coming from the guys they are used to listening to giving the normal inputs on this.” (Interviewee A1)

“I also work with lobbying and mapping stakeholders, so all the time I think about who else I should get support from to help this through. [. . .] I have more experience working with that now, and I tell you that I need to have support from other important persons” (Interviewee F1)

At Company E, new key performance indicators (KPIs) were set up to support the responsible sourcing strategy, yet one interviewee outlined the importance of engaging with sourcing managers to have them actually prioritize these new KPIs in their daily work, which reflects an advocate’s perspective. At Company B, sustainability teams developed an assessment tool able to rate product development projects against their ability to deliver on the UN Sustainable Development Goals which is a relevant reference framework for senior management and thus enables negotiating ecodesign projects in terms that make sense for decision-makers. At Company C, an advocate’s perspective was required to convince internal stakeholders to use a specific material by answering the concerns of engineers, mainly focused on technical aspects, e.g., material properties. At Company D, a coalition of the sustainability manager and LCA people took an advocate’s perspective to broadly engage core business managers in the organization around the topic of circular economy by systematically highlighting criticality to the business through business risks and opportunities associated with it.

4.5. The Prophet's Perspective

Some measures could be found stemming from a prophet's perspective, for instance associated with the idea of "preaching". At Company D, one interviewee mentioned that in their presentations to senior managers, the teams recurrently seek to bring-in sustainability aspects. At Company A, it was indicated that at the beginning of each product development project, which formally includes the conduction and consideration of an environmental assessment in decisions, the interviewee seeks to give a "ten-minute of fame" speech to brief the team about the environmental sustainability challenges associated with products.

"I try to give a speech in a startup project, I ask for 5–10 min, where I deliver the main issues that could be from our yearly environmental report. But it could also be like mass flows. Pointing out the importance and that could be something like that. Ok, we produce so much waste; we produce CO₂ from products developed 5–10 years ago. That is because we still produce these products and they still involve waste and so on. So, that is my key point, so we very much like to reduce waste, and energy consumption is important for our whole CO₂ account. It is now that we have to do it. And also, as we are still producing products designed and developed even 20 years ago, things that we talked about before about the environmental awareness from our user side, in 20 years they will still use the products that we developed today and in 20 years, they may have a lot of high requirements to use of bio-waste, recycled waste, reduced packaging or so. So, I ask for these 10 min of fame when we start and it is really well taken." (Interviewee A2)

Associated with the idea of having trusted people from the product development community speak up for environmentally preferable solutions, an interviewee at Company A also seemed to indicate the symbolic importance of such people taking the lead on ecodesign topics, aligned with a prophet's perspective.

"If they start telling new stories then that time, I think that management will start softening up as well. It's a question of followers. So we start to get the specialists to dance and at some point, even management will as well." (Interviewee A1)

Changing common beliefs about products was mentioned at Company D, where false ideas about products are sought to be changed, similarly at Company C where new truths about products are sought to be established by environmental teams. Changing the common belief that sustainability is necessarily associated with higher costs was also highlighted as a need at Company G. At Company A, efforts are on to change the common beliefs among product development teams that environmental experts can influence product sustainability performance solely by conducting environmental assessments during the product development process. This reveals that the establishment of a procedure formally bringing environmental aspects in the product development process may not be sufficient to push the ecodesign agenda in the organization. The idea of leveraging "what works best" in terms of communication in the organization was reported at Company A and Company D, also stemming from the prophet's perspective.

"I mean the core of our traditions and values is to have something you have you can feel, touch, hear or see. That is always better than a long report. So we tried to do it better and as concrete as possible. And based on that, we had a pilot case running in [a certain market country] during the analysis so we were working very closely with them on this." (Interviewee D1)

4.6. Indications of Relations between the Different Lenses of Organizations

In several cases, measures from an advocate's, catalyst's or prophet's perspective seemed to develop in the absence of an architect's approach at the company. For instance, Interviewee F1 reported that, so far, the inclusion of environmental criteria in product development had been "mostly about convincing the right people" (advocate's perspective). At Company E, both interviewees indicated the

absence of procedures for ecodesign in innovation processes and reported that their work is much about supporting and chaperoning companies which are eager to act and that their approach should not give the impression to “dictate” managers (catalyst’s perspective). Interviewee D2 reported that she recurrently seeks to bring-in the focus on sustainability aspects in her presentations to senior managers (prophet’s perspective), in a context where no specific direction or target come from a top-down perspective for product development.

Measures pertaining to the architect’s perspective were considered or expected in several instances to facilitate other perspectives, especially the advocate’s perspective. For example, formally incorporating sustainability in the organizational system was expected to provide the official scene for prioritizing time and resources on searching environment-friendly solutions at Company G (Interviewee G2). Having corporate environmental targets was indicated to raise sustainability up in agendas throughout the organization at Company B. Interviewee E2 indicated that the establishment of a sustainability strategy had been a facilitator to bargain sustainability implementation with managers. Adding an ecodesign procedure to the product development process at Company A seems to have made it “normal” for project teams to look at environmental criteria throughout the project which may be interpreted as the influence of an architect’s measure on the prophet’s perspective.

We noted some instances where from a prophet’s perspective, interviewees indicated methods which “work best” at their companies and how the latter were actually leveraged in measures from the architect’s or advocate’s perspective. Numbers and graphs are the normal way to display information at Company A, and in that sense integrating LCA in the product development process fits well with the scientific culture of the company as indicated by Interviewee A1. At Company D, concrete experiments are in the DNA of the organization, hence demonstrating the urgency for the company to integrate circular economy principles through a pilot study was found relevant, as reported by Interviewee D1.

We found a set of instances where the advocate’s, catalyst’s and prophet’s perspectives seemed to act as facilitator for, or to complement the architect’s perspective. From the catalyst’s perspective, we noted for example the use of participatory approaches to design how to add ecodesign procedures to the current product development process together with product development teams (Company B; Company C). We also noted the influence of employees’ own aspirations for ecodesign on the actual efforts deployed in developing solutions in projects, even if environmental assessments are formally part of the process, and thus the importance to intensively support those who are eager (Company A). From the advocate’s perspective, we observed for instance a need to secure resources for more prospective projects to complement what can be done in common product development projects (Company A), and the idea that setting up new performance indicators is not enough to have people prioritize them (Company E). We also noted how taking an advocate’s approach and putting efforts on those product development projects with a promising business case allows getting the marketing department onboard, and thus complement the architect’s measure according to which an LCA must be conducted for each product development project (Company B). Finally, the prophet’s perspective was associated for example with fighting misconceptions about who has the ability to influence product environmental performance in product development projects, and thus an important lever to encourage project teams to actually design environment-friendly solutions and to actually build on LCAs conducted for each project as a decision-support tool, rather than a mere documentation exercise (Company A).

5. Discussion

5.1. Presence of the Four Lenses of Organizations

The architect’s perspective was evidently present in the results and directly corroborates the common recommendations from academia on integrating ecodesign aspects in the company’s structure and processes [11,12,19,21,64,65]. We further noted the idea that strategies and goals need to be translated or broken down in lower levels of the organization, for specific business areas or on a project

basis, which aligns with findings from earlier work [17]. The presence of the architect's perspective was further found in relation to challenges experienced by companies working with sustainability, about the difficulty to set a direction, doubts of where to set priorities and what KPIs to measure; calling for an architect's perspective to establish rational priorities, indicators and goals [12,28,62]. The importance of having capabilities specified in the company's organigram was highlighted at Company D which echoes with the findings of Boucher et al. [39]. On the other hand, we found that the discussion around having environmental targets for products varied depending on the context of the company, and more particularly on the nature of its products and drivers to develop environment-friendly products. In the present study, we could observe that in the case of ameliorative products [88], i.e., which inherently address sustainability-related needs (e.g., products developed to save energy or products developed to improve the life of seriously ill people), the development of a strategy related to products or performance targets which would include a broader range of sustainability issues was not a priority. Taking into account companies' strategic drivers to design relevant ecodesign integration approaches was also highlighted in earlier academic work [11]. Such insights from the present study are interesting to put in the perspective of literature insights which identified clear environmental goals, both at organizational and product development project level, or establishing environmental policies and targets for products as key success factors for ecodesign integration and green product innovation in companies, respectively [64,89].

The results regarding the catalyst's perspective align with earlier studies recommending participatory approaches [21,29]. The idea indicated at one case company consisting of framing problems in terms engineers are familiar with, e.g., as an engineering problem, could be considered as a form of nudging, i.e., leading employees towards certain choices without inducing guilt or being prescriptive [18]. Also matching earlier findings, the need for increasing comfort of teams with the topic was evoked in several instances [28]. The advocate's perspective was clearly present in interviewees' elaborations about ecodesign integration, which contrast findings from studies on general managers' approaches [56,57]. The prominence of challenges for ecodesign integration related to resource allocation, tradeoffs management and low priority on senior management agenda, may explain a high focus on an advocate's perspective from ecodesign proponents. The importance of building the "business case" for sustainability and presenting product environmental information in terms which make great sense for the business was also acknowledged in existing literature [13,71,90]. Interestingly, we found a somewhat lower presence of the prophet's perspective in measures indicated at the case companies. Earlier studies in the general management literature found that managers did not make extensive use of the symbolic lens [48,56,57]. The confusion around who has the responsibility and ability to influence the product environmental performance mentioned at one case company was previously highlighted by Johansson and Magnusson; in their study, it was identified as driven by the existence of a separate work stream dealing with environmental aspects in the investigated project [65].

5.2. Relations between the Lenses of Organizations

Our findings regarding the relations between perspectives of organizations interestingly echo with different aspects outlined in existing literature on ecodesign integration. In earlier academic work, scholars have highlighted the facilitating role of architect's measures on the other perspectives of organizations. Measures from an architect's perspective, e.g., integration in process and targets, have been found to result in a change in mentalities and higher motivation among employees [91]; more familiarity with, cooperation around, understanding and acceptance of ecodesign practices [12]; more cross-functional cooperation, networking and understanding of each other's roles [65]; higher priority for ecodesign in agendas both of product development teams and senior management [65,92]. In the present study, we found similar examples of a facilitating role played by architect's measures, yet no example of facilitation over the catalyst's perspective were mentioned. The facilitation was mostly emphasized by interviewees in the context of prioritizing ecodesign in agendas and daily work, hence on the advocate's perspective.

The observed facilitating or complementary roles of the advocate's, catalyst's, and prophet's perspectives on architect's measures match conclusions from other studies in which informal aspects of organizations were emphasized. Building on interviews conducted at four large companies, Kivimaa argued that the sole use of codified practices, e.g., LCA, does not guarantee a common understanding within the organization and emphasized the role of people-based approaches, i.e., cross-functional integration and training in environmental issues, for environmental integration in innovation [27]. Based on field work in two large companies, Skelton et al. concluded that the use of boundary objects for ecodesign integration, e.g., environmental improvement targets, which can be associated with an architect's perspective, "only establish specific instances where the environmental specialists can communicate around ecodesign and increase the engineers' level of awareness" [29] (p. 54). They further found that the use of boundary objects was not sufficient to integrate brokers, i.e., people working in functions supporting ecodesign integration, inside the product development community; neither to change the behavior of the product development community [29]. Arguing that nowadays managerial approaches tend to place less emphasis on command and control mechanisms (architect's perspective) to the benefit of increasing team autonomy, Brones et al. highlighted the need for "soft" mechanisms to lead the organization towards green innovation practices, e.g., fostering employees' engagement [18]. The insufficiency of architects' measures to guarantee successful ecodesign integration was also highlighted by Dekoninck et al. who indicated that solutions to address ecodesign integration challenges were often about introducing new tools, to the detriment of understanding why employees may lack motivation or be resistant [13].

Earlier academic studies exploring and comparing companies' trajectories of sustainability integration found that they did not all use architects' versus informal measures to the same extent, but rather adopted approaches which would best suit their organizational culture [76,93,94]. In the current study, all case companies seemed to agree to the importance of measures from the architect's perspective and none mentioned an integration effort solely based on informal aspects. Yet, the idea of matching the company's culture appeared in the mentioned prophet's measure consisting of using "what works best in the organization" to support ecodesign integration. The relative importance of measures from different lenses of organizations in different company contexts could be relevant to investigate in a larger sample of companies.

5.3. Influence of Interviewee Position and Company Context

Interviewees involved in the present study had either a sustainability-related position in their company or worked in a core business function and had some interest in pushing the ecodesign agenda in their organization. All interviewees indicated measures related to the architect's perspective. However, the formal integration of ecodesign aspects in the company's activities was one of the focuses of the interviews, and hence could have biased to some extent the perceptions of interviewees towards the relevance and need for measures from the architect's perspective. The advocate's perspective was also present in most interviews. Considering the sample size, it is difficult to draw any firm conclusion regarding the influence of the interviewee's position. We found that the interviewees in sustainability functions mentioned measures pertaining to at least three perspectives and more than half of them to all the four perspectives of organizations. On the other hand, more than half of the interviewees in core activity functions indicated measures from three different perspectives, and the others from one or two. Seniority in the organization or experience with working with sustainability-related topics did not seem to influence the number of lenses expressed by interviewees, as we did not observe clear differences in lens coverage between experienced and less-experienced interviewees. Yet, the influence of the above-mentioned parameters should be further studied in future research based on direct inquiries of the four lenses, as in the present exploratory study only weak indications could be retrieved.

The present work constitutes a Nordic case study as all case companies were in Nordic countries. This regional focus may have influenced the extent to which the different lenses of organizations could be observed. For instance, one interviewee from Company E referred to a Nordic style of working

when describing that she seeks to empower employees by making them “*understand why they need to do something and what is expected from them*”, before letting them “*find out what is needed to be done in detail*”. This echoes with observations reported in earlier work touching upon the relative freedom of employees in Nordic organizations on how to achieve given targets [95], and could be in favor of the catalyst’s perspective. At Company A, it was emphasized that there is a *consensus culture*, which leads to discussing solutions rather intensively in development projects. At Company D, one interviewee indicated that the organizational structure is rather flat and that they “*can go directly from [their] department to another department*”. Both these factors could create a favorable ground for approaches stemming from the catalyst’s, advocate’s, and prophet’s perspectives. On the other hand, the companies included in our sample are large market players, externally recognized for their sustainability efforts (e.g., listed in DJSI). From this perspective, the coverage of lenses found in the present study may not be representative of smaller companies or companies with less mature sustainability approaches.

5.4. Limitations of the Study

Only a limited number of interviews could be conducted at the case companies, especially at Company B where only one could be conducted. It is thus important to acknowledge that the phenomenon under study and presented in this article remains closely related to interviewees’ perceptions, which is yet common for this type of research. Deriving concrete recommendations for the case companies would require a larger scope of investigation, but for the present study, the views of interviewees constitute relevant indications about the different lenses of organizations. This work was exploratory per definition and based on a case study design; hence this naturally limits the statistical generalizability of our findings which should be tested in future work on larger samples of companies [82]. Although the interview data allowed for tracking the presence of the different lenses of organizations in interviewees’ descriptions of ecodesign integration at their company, the empirical part of the study remains based on a secondary data source, and thus may not give a fully representative picture of the presence of the lenses. More targeted questions could have yielded different results in terms of lenses’ relative presence. Yet, the absence of questions targeted for each lens may, on the other hand, have been an advantage as it avoided social desirability or prestige biases, which can typically occur in direct questioning settings and imply that respondents tend to answer based on what is most socially accepted rather than based on the truth or on what is perceived as expected by the interviewer, respectively [96]. It also prevented any potential connotations associated with the different perspectives of organizations, e.g., “*architect*” (positively connoted) versus “*prophet*” (negatively connoted). However, future research designs based on direct inquiries of the four lenses, e.g., using a questionnaire adapted from the leadership orientation instrument [48], are needed in order to further our understanding of the role of the four lenses in ecodesign integration in companies.

6. Conclusions

Departing from the need to investigate and support ecodesign integration at companies, while accounting for formal and informal aspects of organizational functioning, we drew on the four-lens view of organizations and explored the presence and relations between the different lenses in ecodesign integration. The study built on interviews of ecodesign proponents at a set of Danish and Norwegian case companies in diverse manufacturing sectors. First, the analysis revealed the presence of the architect’s, catalyst’s, advocate’s, and prophet’s perspectives in the measures mentioned to support ecodesign integration at the case companies. Second, the results provided indications about relations between the different lenses, among which two seemed to stand out: (i) measures from the architect’s perspective seemed considered or expected to provide an official scene for prioritizing ecodesign in the organization, hence facilitating the advocate’s perspective; and (ii) measures stemming from the catalyst’s, advocate’s and prophet’s perspectives were observed to act as facilitator or complement of measures from an architect’s perspective to push the ecodesign agenda at companies. Overall, this

exploratory study suggests that the four-lens view of organizations is pertinent to investigate and support ecodesign integration in organizational contexts.

From a theoretical point of view, our study contributes to the research field of ecodesign integration in companies with a new theoretical perspective stemming from the general management literature. Based on exploratory case studies, this work has investigated the potential of the four-lens view of organizations to support ecodesign integration in companies and brought initial evidence on the need for embracing the different lenses. This is a starting point for future work. Direct investigations of the lenses' presence in ecodesign integration efforts of larger samples of companies in different contexts should be the object of future studies to test the generalizability of our findings and expand our understanding of a multi-lens approach to support ecodesign integration in companies. Notably, interconnections between lenses need further investigation. Furthermore, it could be particularly relevant to (i) identify lenses which are critical, i.e., weakly established although recognized as highly necessary, in the opinion of ecodesign proponents in industry; (ii) study possible correlations between the lenses' coverage in ecodesign integration efforts and ecodesign performance indicators; (iii) study the relative importance of lenses in different organizational contexts, e.g., depending on the company persona [97]. From a practical perspective, our study provides ecodesign proponents in companies with a conceptual framework from the general management literature and its translation into the ecodesign integration context, with concrete measures to support ecodesign integration from the different perspectives of organizations and insights of the relative role of the different lenses.

Considering the challenges associated with ecodesign integration in companies together with the recurrently acknowledged need to account for the specific context of companies rather than providing one-size-fits-all models [18,59,76,98], the development of reflective tools whose primary objective would be to steer reflections from company practitioners about their current situation and challenges, seems a particularly interesting area to explore [99]. From this perspective, the potential formalization of the four-lens view of organizations into a reflective tool for ecodesign proponents is identified as an avenue for future research.

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Appendix A. Themes Addressed during the Interviews

- Current integration of ecodesign in the company: Processes? Tools? Strategies? Goals? Challenges?
- Interactions with other departments on ecodesign: form, challenges, and enablers?
- Interactions with other businesses on ecodesign (suppliers, distributors, customers, reprocessors, competitors, companies in other business areas): form, challenges, and enablers?

Appendix B. Details about the Coding Results

Table A1. Results from the revision of the coding results.

	Number of Reviewed Coded Units	Percentage of Discussed Coded Units	Percentage of Changed Coded Units
Co-author 1	52	12%	4%
Co-author 2	49	18%	6%
Co-author 3	49	39%	18%

Table A2. Lens distribution of coded units identified for each case company. Please note that the total number of coded units varies from one case company to the other.

	Architect (Structural)	Catalyst (Human)	Advocate (Political)	Prophet (Symbolic)	Total Number of Coded Units (=100%)
Company A	36%	19%	33%	11%	36
Company B	53%	16%	32%	0%	19
Company C	37%	26%	33%	4%	27
Company D	54%	7%	18%	21%	28
Company E	59%	21%	21%	0%	34
Company F	67%	0%	22%	11%	9
Company G	71%	0%	13%	16%	38
Total number of coded units	101	26	46	18	191

Table A3. List of second-cycle coding categories in each lens of organizations and examples of associated first-cycle coding phrases. LCA = Life Cycle Assessment; ERP = Enterprise Resource Planning; KPI = Key Performance Indicator.

Second-Cycle Coding Category	Examples of First-Cycle Coding Phrase
Architect's Perspective	
Integrate ecodesign procedure in product development process	"There is a mandatory procedure in product development projects for dealing with environmental aspects"; "The project manager has the responsibility to show environmental documentation at gates"
Acquire/develop tools for decision-making	"Development of in-house LCA capabilities"; "LCA used to compare products with competitors' or earlier generations"
Design strategy related to products	"Need for having sustainability as part of the business strategy, so that teams can take decisions based on environmental criteria"
Set directions/goals/targets	"The company has targets for products at high level"; "Set up a direction to be able to ask some funding to try out some alternative options in products"; "Set up a direction to be able to go all in when scouting for alternative options and have more margin to discuss with suppliers directly"
Develop guidelines related to product development	"Create a shared repository about eco-labels"; "Produce central guidelines for packaging material"
Formally define "sustainability" (e.g., standard, criteria)	"Define what "sustainability" means for the department"; "Define what a sustainable product is formally"
Translate strategy into action plan for specific business units/functions	"Define what the sustainability strategy implies at the function level"; "Develop a sustainability strategy and tailored translation tools"
Translate corporate targets into targets for individual innovation projects	"Breaking down high level targets to innovation project targets"
Create sustainability roles	"Slowly building the organizational structure around sustainability in the organization"
Set up new KPIs	"Set up new KPIs for the purchasing department"
Use a process with more experimental approach	"The set up for the sustainability dedicated project outside the stage gate model of the company is great because decisions can be taken more quickly"

Table A3. Cont.

Second-Cycle Coding Category	Examples of First-Cycle Coding Phrase
Catalyst's Perspective	
Support/chaperon initiatives	"Make sure that the parties continue the project (since it is side track for them)"; "Support individual managers in their attempt to integrate sustainability issues in their work"
Increase comfort of people to work with the topic of ecodesign	"Make material digestible, focus on having teams comfortable discussing sustainability"; "Clarify tasks and implied workload for people to feel comfortable about it"
Build individual awareness of impact of decisions	"Have people understand how their decisions impact the product environmental performance"
Leverage people's aspirations	"Involve people who burn for the topic"; "Specifically support people that are eager to bring change because it all comes down to people's passion"
Participative approach to adapt the product development process	"Co-design with product development teams how the LCA tool will be used in the process"
Frame ecodesign challenges in familiar terms	"Translate ideas into concrete technical challenges to be solved by engineers who are good at it"
Give autonomy	"Tell people what their end goal is and let them find the way there"
Trigger people/"plant seeds"	"Trigger people by evoking the ecodesign topic"
Advocate's Perspective	
Align with business/stakeholders' agenda	"Identify critical resources in ERP system, match with business case to convince sourcing manager"
Negotiate prioritization of ecodesign in agendas	"Need for more priority on sustainability aspects when prioritizing projects"; "Bargain with management for sustainability KPIs to actually be prioritized in purchasing"
Emphasize criticality/emergency for business	"Make top management understand the underlying risks of sustainability aspects"
Target efforts/"pick battles"	"Target areas of the organization where change is easier to operate, e.g., in product maintenance rather than product development"; "Focus on high potential for sustainability story, sustainability needs to be shown as a win to marketing"
Ally with/get support from relevant people in the company	"Get people that are listened to, to speak up for environmentally preferable options"
Have answers to all technical questions	"Seek good arguments from expert judgements"; "Convince people that something is technically possible"
Leverage network in the company	"Leverage personal relationship to have people work outside the normal working flow"; "Create a network of sustainability responsible people in the organizations where they share knowledge, best practices and can collaborate"
Secure present resource allocation for long term/more prospective objectives	"Need prioritizing resources for projects specifically targeted at finding alternative to conventional plastics because no obvious green solutions"; "Need to invest in knowledge and competence for sustainability even if it is long term"
Leverage existing umbrella projects	"Leverage existing project as an umbrella for activities so that resources and momentum are already there"

Table A3. Cont.

Second-Cycle Coding Category	Examples of First-Cycle Coding Phrase
Prophet's Perspective	
Manage beliefs/"truths" in the company	"Change mindset that sustainability is a cost"; "Challenge common beliefs in the organization by delivering data"
Change perceived vision/mission of the company	"Change what people believe they are working for"; "Spread around that the company has ambition for sustainability"
Leverage "typical ways of doing"	"Use experiments which are in the DNA of the company to show relevance of ecodesign aspects"
Preach in the company	"Use a 10-min of fame to brief teams about environmental challenges at beginning of each project"; "Spread around the concept of circular economy (make sure everyone knows what it is about)"
Provide inspiration from outside	"Gain insights from young generations' thoughts on sustainability"; "Bring external inputs to change mindsets"

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PAPER VI. COLLABORATION

- Authors:** Faheem Ali and Casper Boks
- Full Title:** Role of internal collaborations and its impact on Design for Sustainability implementation in companies
- Published in:** Proceedings of ERSCP 2017
- Purpose:** This paper studies the different collaboration practices happening within companies involved in DfS implementation and identifies different factors affecting it.
- Method:** This explorative paper takes insights from literature on collaboration practices in New Product Development (NPD) and preliminary results from 15 interviews conducted in Norwegian and Danish companies.
- Results:** The major findings of this preliminary study are two fold: it was observed that the collaboration practices within the company during DfS implementation was very similar to that observed from similar studies on NPDs. Secondly, two major category of factors affecting collaboration was identified and listed, namely factors inhibiting/facilitating collaboration and factors influencing the overall nature of collaboration in companies.
- Contributions:** The paper was able to bring forward the discussion on non-technical aspects of DfS implementation by identifying factors affecting internal collaboration in companies and how the contextual factors played a role in it. These observations were proposed as a starting point to explore the topic collaboration further in companies involved in DfS implementation.

Internal company collaborations and its impact on Design for Sustainability implementation in companies

Faheem Ali *

*Department of Design, Norwegian
University of Science and
Technology (NTNU)
Kolbjørn Hejes Vei 2B, 7491,
Trondheim, Norway*

Casper Boks *

*Department of Design, Norwegian
University of Science and
Technology (NTNU)
Kolbjørn Hejes Vei 2B, 7491,
Trondheim, Norway*

Abstract

Academic and industrial discussion on effective and efficient implementation of Design for Sustainability (DfS) has been an ongoing process for some time. Nevertheless, recent empirical studies note that the need to address issues flagged by decade old research on the topic is still relevant and elusive of successful solutions. Addressing the “soft-side” issues of the companies has been accepted has a valid point of departure for DfS implementation. This research paper, supported by empirical data from 5 case companies, takes this stand point further by exploring the different factors that influence collaboration among departments in a DfS project. In addition to that, contextual elements of the companies that could possibly impact the collaboration are also presented. Based on these findings the paper concludes with a discussion on possible company personas and how a better understanding of company personas can streamline DfS implementation.

KEYWORDS

Design for sustainability, empirical study, internal collaborations, challenges, facilitators, company personas

1. INTRODUCTION

The need for sustainability considerations in product design activities has been gaining greater acceptance in industries. One such step towards more sustainable products has been the Design for Sustainability (DfS) initiative. Even though the concept of DfS has been a focus subject in both academia and industry alike, academic reviews suggest that DfS implementation has faced a number of barriers and challenges in actual implementation stages. A part of these barriers has been associated with the technical aspects of the product such as material selection, toxicity, utility, performance etc. The other part of academic discussion has focused upon the contextual human factors existing within and beyond the company boundaries that can have a possible impact on DfS implementation. Solutions put forward by academia to overcome these challenges have been mostly in the form of standardized DfS tools, checklists and matrices (Pigosso et al., 2013). However, most of these solutions have failed to create desired results or have not been widely used in industry. This is mainly because most challenges and enablers for DfS implementation vary according to the context of the company and standardized solutions are less likely to be effective in such situations (Baumann et al., 2002; Knight and Jenkins, 2009).

These contextual factors, termed as “soft-side” factors in some academic literature (Boks, 2006), include the cultural, linguistic and organizational elements of the company and its employees, among others. Challenges associated with these “soft-side” factors have been identified to be lack of commitment towards sustainability initiatives, absence of proper training and required skill set, insufficient and lackluster communication patterns in the organization, decision making styles, empowerment levels existing with the company, absence of proper change management practices etc. (Baumann et al., 2002; Stevels, 2007; Verhulst and Boks, 2012).

This research work tries to understand these organizational contextual elements from an empirical point of view based on 15 interactive interviews carried out with companies having a DfS focus in their product line. The authors try to identify what collaboration practices exist within these companies, in particular related to DfS implementation, and which stakeholders are involved in such internal collaborations. Further, the interviews also aimed to uncover how these collaborations

~~happen and what challenges arise during this process. The research aims at contributing to the~~

ongoing academic discussion on the topic by better understanding the various dimensions of the company context that contribute to such collaborations. These could include the organizational structure, style, management commitment etc existing within the companies. Drawing from the concept of “personas” in user centered design studies, the interview analysis also tries to develop a categorization of companies based on it’s “persona”. A preliminary framework of company personas shall be presented based on the different persona dimensions that can be identified from the interviews.

2. LITERATURE BACKGROUND

2.1 Internal collaboration in companies

The need for collaborations in the context of new product development (NPD) has been well discussed and researched. Kahn (1996) explores the influence of interdepartmental integration in companies involved in NPD, the survey results show that increased interdepartmental collaborations, presented as a sub category of interdepartmental integration (the other sub category being interactions) between the departments showed a significant performance change in the processes and post launch follow up of the products. Collaborations between departments involved in the product development processes have shown to improve the communication, dependability and remove the uncertainty issues associated with product development processes (Kahn, 2001; Souder et al., 1998).

Literature on the topic outlines these collaborations to involve a range of formal and informal activities that happens within the organization. These include the regular team meetings, informal discussions on the project topics, sharing of resources both tangible and intangible, exchange of tacit knowledge etc. Collaboration activities in general relate to the joint activities between a number of departments towards achieving a common vision, complemented by a mutual understanding of the topic and collective goals (Kahn, 1996). It is our understanding that, as such activities are seldom defined within an organization, it often requires joint efforts, trust and interrelationship to sustain over the longer period of time. In the following sections of this research paper we investigate these different contextual elements that has helped the case companies sustain collaboration, if any could be identified.

Further probing the academic discussion on interdepartmental collaborations in literature on organizations and strategic management, we find that the applicability and need for the same has been over-emphasized in multiple scenarios. Companies involved in NPD activities with strong collaboration practices within their departments were found to be more effective and responsive to the market demands, user expectations and in resolving the engineering challenges (Oswald et al., 2012). Thus, based on the brief literature review carried out as part of this work, we can safely hypothesize that internal collaboration has an important role in determining the success or failure of challenging projects in companies.

2.2 Need of collaboration in DfS implementation

The complexity and necessity for the need of collaboration in DfS projects is even more significant because DfS projects also create the need to explore multiple domains such as ecology, environmental impact, resource efficiency and so forth. These areas are otherwise most often ignored in a design milieu driven by user experience and utility of the product (Brones et al., 2014; Luttrupp and Lagerstedt, 2006). Further, DfS also demands a longitudinal integration of sustainability concerns at each stage of the design process, thus adding the sustainability dimension to the usual ones of cost, time and quality forces the design activity to be collaborative and act in cross-functional teams (Johansson, 2002; Rio et al., 2013).

Earlier researchers who explored the role of the “soft-side” of DfS stated the need for focusing on the organizational context and multitude of factors surrounding the people involved in the implementation process. These factors involve improved communication patterns, conflict resolution practices, controlling and guiding the change management practices associated with DfS

Hence, for the purpose of this paper, collaborations are defined as the interdepartmental activities between multi-domain actors involved in the product development process happening inside the company with an environmental aspect to it.

3. METHODOLOGY

The empirical data presented in this paper is based on 15 interactive interviews that were carried out in 5 different companies. As the interviewer had limited control over the background of the respondent and also internal collaboration practices varied between companies, semi-structured interviews were carried out to factor in this (Yin, 2013). Each interview lasted between 60-90 minutes and was recorded and transcribed for analysis. As the unit of analysis in this paper is the company and the internal collaboration activities happening within the company, an overview of companies interviewed is provided below:

Table 1 Interview respondent details

Company	Industry	Geographic Presence	Employee Size
Company A	Medicare supplier	Worldwide	10000
Company B	FMCG	Worldwide	15000
Company C	Renewable energy technology	Worldwide	8500
Company D	Construction	Worldwide	10000
Company E	Biotechnology	Worldwide	7000

Of the 15 interviews, 8 interviews were carried out with Company B and 1 interview at Company E. Two interviews each were carried out in the other case companies. All the respondent companies had a sustainability focus in their activity, though with varying range of intensity.

Though interview has been an established method in qualitative research, most respondents tend to be more generic in their answers and often lack the contextual dimensions of it while replying to interview questions (Noordegraaf, 2014). Further, effectiveness of interviews is most often hindered by limitations by verbal communication skills of the respondents (Affleck et al., 2013). Thus creating a gap between what they say and what they actually do (Courage and Baxter, 2005). Therefore, in addition to the usual question answer sessions, an interactive map was used to elicit detailed and structured information from the respondent. The effectiveness of such a method is being discussed later in this paper. An illustration of the interactive mapper used as an aid during the interview is show below in Figure 1. The map was used to maintain a balance between the verbal and graphic elements of the interview. The respondent was asked to identify a set of internal actors that their department interacted with when it comes to a Dfs implementation project. Then, they were asked to pick 2-4 major actors and highlight the different challenges and enablers they have experienced in the collaboration activity using the mapper. The bullet points mentioned in the mapper was used to drive the discussion.

4. STUDY FINDINGS

From the respondents that were interviewed, 7 respondents and their departments were directly involved in sustainability activities to a large extent as part of their work. Among the other departments that were represented in the interviews, product developers and project managers formed the next biggest group. The functions of other respondents vary between communication directors, EHS persons, communication directors or R&D managers.

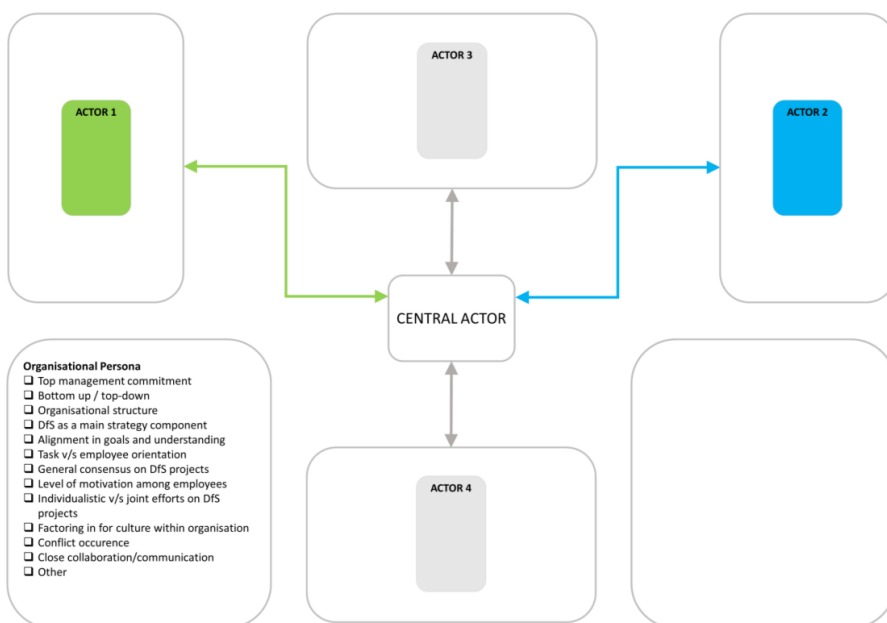
4.1 The facilitators of Dfs collaborations

Despite the visible differences between the activities of the companies interviewed and their field of work, there was some overlap between the different internal actors the respondents collaborated with during the Dfs implementation process. The first part of the interview questions

tried to identify these different actors and the factors that facilitated the collaboration between them in DfS implementation projects.

Collaboration activities in all the case companies involved regular project team meetings, joint pre-project meetings to define the project goals and product requirements, informal gatherings. Some of the case companies also followed formalized PD process such as stage gate models where sustainability assessments were carried out in all stages. The sustainability assessment experts in company E and provided

Figure 1 Interactive mapper used in the interview process



All the interviews were recorded and transcribed using Nvivo and each part of the interview was categorized based on the general themes of the discussion, where relevant quotes were extracted to cross analyze the findings between the case companies.

In a previous research looking into factors that enable and inhibit integration of various activities in companies, Pagell (2004) classifies the factors under following major headings; structure, culture, communication, measurement and rewards, consensus of the idea and plant size. Although that research was carried out in a different context of integration of operations, purchasing and logistics, these categories were used as a basis for interpreting the interview findings. As most companies did not have exclusive DfS projects in their portfolio, interviews also considered product development (PD) activities where sustainability issues were addressed to some extent. Thus, a general classification of the different factors that facilitated the internal collaborations during such projects, as derived from the interviews, is presented in Table 2.

As seen from Table 2, skill set requirements for achieving the sustainability goals of the products was the most influential factor that facilitated collaboration among the different departments. Interviews also revealed that companies that exhibited a common interest for the topic among the actors and an inherent business strategy promoting sustainability found it easier to collaborate among themselves, as illustrated by the following quote.

“That was the first time we have been working with the coating engineers, so some it included working with new people, we were colleagues, we have probably never met each other, passed by in canteen may be. That is that...I mean this knowing people. I guess a lot of people assume that it is a good idea ...so we also need to know that they have been proved somehow, before starting to assign a person to a project. So that is

may be also part of the initial resistance you could say (Sustainability Assessment expert in-charge – Company C)”

Table 2 Factors that facilitate collaboration in DfS projects

Company	Overall strategy	Organization's Structure	Top management	Sustainability champions	Common Interest	Skills required	Facility layout	Market demands	Recognitions
A	-	x	-	-	-	x	x	-	-
B	x	-	x	x	X	x	-	x	-
C	x	-	-	x	X	x	x	x	-
D	x	-	-	x	X	x	-	-	x
E	x	x	x	x	X	x	x	x	x

Further, to establish a clear structure of collaboration and to emphasize the DfS aspects in the product development process a clear strategy with sustainability goals incorporated in it was found helping, as seen from the following quote:

“I think that has been an advantage (to be placed in top management), allows us to work across. Which is really super important. I don't really know where else should we be really anchored. Of course, I would think we could be anchored in project management or in marketing. But that would make it more difficult for us to work across the depts. Like in any env. dept / sustainability dept, we need to work across. (Sustainability assessment expert (SAE) – Company E)”

Apart from most generic influential factors identified from the literature, companies D and E also identified the presence of rewards and recognitions of sustainability activities as a motivating factor for the different actors to collaborate more on the DfS issues. Instances where colleagues were awarded for coming up with sustainable product solutions were recognized or awarded were used as examples in future project meetings to garner larger support (company E). Presence of individuals or groups motivated in sustainability issues made it easier in certain occasions to push up the agenda to the top management and see a company wide change in the way PD was done (company D).

4.1 The contextual elements and collaboration

The second part of the interview explored the various contextual elements of the company that could have possibly lead to their current experiences with DfS implementation and associated collaboration activities. Previous research has shown that companies, like users in a design context, can have personas that distinguish them from the rest. Ali et al., (2017) categorizes these contextual elements as following:

- Company background and activities – Its business proposition, strategy, history, mission, vision and goals
- Demographics – in-house tangible and non-tangible resources, tacit knowledge, tools, methods, skills and training
- Market conditions – push and pull forces that determine the product portfolio
- Political undertones – consensus among employees, power relationships, motivation, attitude towards sustainability issues
- Organizational structure – hierarchy, reporting activities

Similar elements were observed among the companies interviewed, where despite the similarity between the challenges faced in collaborations, there were certain salient features that distinguished them. A visible difference was the difficulty in motivating and convincing the concerned departments to include DfS in PD process. In the case of company E, it was a more established goal to have more sustainable offerings, thus the idea to have a DfS dimension in PD was inherent in it, making it easier. Whereas, in company B it was initiated following a common

interest by the R&D (sustainability champions in the company), but it was found challenging to push it further to other departments.

"Oh, it is driven from the top... I don't know if there is a consensus in the whole company. But I do think that it is the right approach, because, if it is not a top down, it is really hard. It is really really hard to go bottom up, I can tell you from experience. Of course, you can try to push in the doors, but without management commitment. It is mostly because, you cannot make them prioritize (SAE Company-E)."

"No, because if we have the sustainability strategy as part of our business strategy, that is something we would very much like. Because then it would be much easier to take decisions which is good for the environment or social conditions. Because it is kind of our guidelines to do so. But it is not and it becomes a fight every time you try to do it. (Senior Project Manager – Company B)"

As seen above, despite having a top down push for DfS focus in their PD, the respondent felt that since there is a lack of proper definition or consensus of what sustainability means to their activities, it was difficult to expect a uniform understanding among the employees. Another distinguishing factor that promoted collaboration in DfS projects was close geographic proximity of all the relevant departments.

"It took me 4 hours to come here so they are quite far away and of course we can speak on the phone but if we had some people that had special skills in terms of sustainability uh... nearer to this part of the organization to the R&D, the Technology Department then I think it would have more focus. (Technology Development Manager, Company D)"

Departments that were co-located in one location found it easier to collaborate, while as in company D, companies that were separated by geographic distance found it a hindrance for more colloquial discussion around DfS issues.

5. DISCUSSION

The interview findings presented in this paper corroborate the ongoing and previous academic discussion on the importance of contextual elements in DfS implementation. Johansson (2002) reviewed literature to identify various factors required to integrate DfS in the product development process. Clear environmental goals, communication, organizational structure, presence of environmental champions etc. were among the factors identified in the paper. Later research on the topic also underlines the importance of such "soft-side" elements in the companies (Boks, 2006; Brones et al., 2017; Verhulst and Boks, 2012). Despite the passage of time and further research in the topic, these issues continue to be unanswered to a large extent. The academic response by developing DfS tools, checklists and matrices have also been mostly unsuccessful in addressing these issues (Pigozzo et al., 2013), for most tools have remained standardized solutions with limited applicability or usability in dynamic contexts of its actual usage.

Given these ground realities, it is relevant to probe the idea of "company personas" explored in this paper through internal collaborations happening in DfS projects. As can be seen from the findings, though all companies collaborate among various departments in more or less similar manner, the challenges they face in these collaborations can be traced back to the contextual factors existing in these companies.

A few of the case companies with a highly motivated CEO found it easier to overcome initial inhibitions in PD with sustainability focus. At the same time, they found it difficult to operationalize these goals due to the lack proper tools/methods to inform them and the rest about the best decisions. Whereas, as seen in case company B, despite having highly motivated employees in the lower level of management some of them found it hard to convince the other departments on sustainability focus. This was primarily because of a lack of sufficient skill sets to assess their current performance and support from the top management. On the other hand, companies C and E, whose business is to provide renewable energy technology and to replace chemicals with bio-based solutions respectively, found it difficult to explain the clear sustainability focus in their products. Rather, they justified the absence of that by saying, *"our business is green solutions, so what we do is a step towards that"*.

It was also observed in the interviews that individual recognitions or incentives were used as motivating factor for members in future instances of DfS implementation. Similar observations have been made in organizational literature where financial incentives motivated project teams to perform better and faster.

Based on these and other observations not discussed here because of space limitations, we constructed three possible company personas, based on imaginary company portfolios.

Table 3 Factors that facilitate collaboration in DfS projects

Persona Dimension	Persona 1	Persona 2	Persona 3
Company background and Activities	A historically family owned MNC. Less priority on sustainability	A startup based on green performance, inspirational CEO	A localized business firm, No focus on sustainability, but specialists in their field
Demographics	Some environmental champions, reliance on third party EIAs	Highly skilled workgroup on DfS, fully integrated PD	No in-house resources, green washing silently promoted
Structure	Top down hierarchical structure, centralized policy approaches even in regional offices	Matrix organization facilitating easy resource sharing	Messy and informal communication patters,
Political undertones	Strong power imbalance between offices and positions	Visible consensus and empowerment among employees	Job struggles, fear of being absorbed by larger companies
Market Conditions	Market leader in most segments	Insignificant market share until now, but growing customer base	Specialized customer base and exclusive, high-end image

As proposed in table 3, defining company personas based on the contextual dimensions of the companies is found to be an interesting proposition to approach the case of DfS implementation challenges. Such a categorization can help both academic and industrial practitioners of DfS to approach the case of each company in a more customized manner. Companies can identify themselves to one of a certain persona and use it to flag the hotspots in the organization and approach the case accordingly. Researchers and even consultants may become inspired to address issues around DfS introduction and implementation in a more targeted way.

It is also noteworthy to comment on the interaction mapper used as part of this interview process. A few of the respondents (all with sustainability background) liked the idea of jotting down their views and took initiative to use the map all through the interview. The aid was found to be effective in all interviews except two, who preferred talking about the collaboration activities instead of writing them down on post-its. In other cases, a few respondents were initially apprehensive of choosing the right wording while describing challenges or complexities with their top management. We understand that it was a case of being more politically correct in what they write than in what they say. Most often the post-its the respondents placed in the map helped them structure their ideas and bring new dimensions to the interview.

6. OUTLOOK

This paper presented an overview of different factors facilitating collaboration between departments involved in a DfS project. The paper also argues based on empirical findings that context of a company plays an important role in enabling or inhibiting the implementation process, thus proposing that companies need to be studied in their context and defining company personas is a way forward in addressing the challenges identified for “soft-side” of eco-design. Such an approach, we believe, will enable practitioners, academicians and companies in making better

informed decisions on the actual requirements of tools, guidelines and consultancies companies require to deliver their stated sustainability goals.

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