

# **Towards Strategic Sustainable Product Development: Challenges and Opportunities for Communicating Sustainability in a Value Chain**

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## **Abstract (350 words)**

Sustainable product development and sustainable manufacturing have been considered one of the main enablers towards addressing the global sustainability challenge. Sustainable communication among stakeholders in a value chain is believed to be an important catalyst for effective collaboration towards reaching sustainability goals. However, research that focuses on sustainability communication in the context of product development remains scant.

Sustainable product development literature has traditionally examined decision-making and value-adding activities without explicitly considering sustainable communication as part of these. A great variety of tools, methods and frameworks have been developed to enhance understanding of the complex sustainability challenge and support decision-making in product development and consumption. However, there lacks a complete picture of sustainability communication in product development context from a practical point of view.

This paper aims to provide an updated overview of the existing practices in sustainability communication and related support tools. The overarching research question was defined to be: How to improve support for sustainability communication among stakeholders in a value chain?

Findings reported in this paper are drawn from a conceptual literature review and a workshop with participants from two large product development and manufacturing companies. This paper outlines an overview of sustainability communication tools on operational, tactical and strategic levels in relation to stakeholders in the upstream and downstream of a value chain. It was found that the biggest communication gap lies between product developers and consumers. This led to the specific question of how can consumers communicate sustainability related information to product developers to accelerate the development towards more sustainable solutions? Challenges of bridging this communication gap, as well as challenges for applying support tools in the product innovation process are delineated. Based on the discussion with industrial partners involved in the workshop, a number of success factors of support tools were identified. Opportunities for developing sustainability communication solutions are proposed with an emphasis on connecting consumers with product developers. Two future research

directions are suggested to be i) further investigation into consumer perception to improve information design on different levels, and ii) closing the communication loop with consumers using digital technologies such as the internet-of-things.

***Keywords: Communication, sustainability, decision support tool, value chain, sustainable product development***

## **1 Introduction**

Sustainable product development and sustainable manufacturing have been considered as main enablers towards addressing the global challenge of sustainable development (Petala et al., 2010; Tukker et al., 2008). In early product development stages, a wide range of decisions made by various stakeholders influence the full life cycle of a product (McAloone & Tan, 2005), which collectively has a significant impact on the planet. Design decisions made by various stakeholders, for example designers, engineers, suppliers and manufacturers, largely affect the environmental impact incurred from production and the sustainability performance of products. Consumers also play a significant role in deciding how the products are used and disposed.

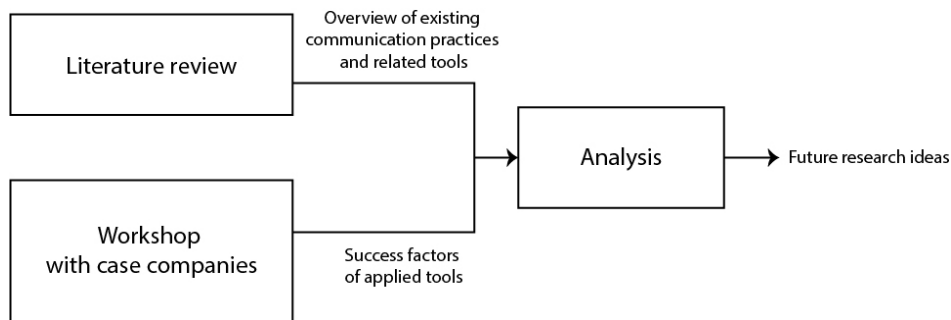
Negative sustainability impacts might be prevented or mitigated if the stakeholders within the value chain can communicate effectively and make informed decisions. A value chain is a network of companies, organisations, or actors directly or indirectly involved in the product's life cycle and includes suppliers, service providers, users/consumers, recyclers, etc. (Pigosso et al., 2015) Sustainability communication is believed to be an important catalyst for effective collaboration towards reaching sustainability goals strategically and tactically (Töpfer & Shea, 2005). To be able to efficiently and strategically work towards sustainability, it is important to define and agree on what sustainability means for a company (G. Broman et al., 2000) to ensure that a complete sustainability perspective, including both ecological sustainability and social sustainability, is used to guide innovation processes rather than single aspects of sustainability. Strategic sustainability aims for a well-defined sustainable situation and gives guidance for how to work towards it in a strategic step-wise approach (G. I. Broman & Robèrt, 2017). Shorter-term tactical decisions need to be combined with a longer-term context, meaning that the tactical decisions are aligned with the longer-term strategic goals, and thus better support moving towards more sustainability-driven product innovation.

A definition of 'sustainability communication' is given in the book *Sustainability Communication - Interdisciplinary Perspectives and Theoretical Foundation*, written by Godemann and Michelsen (2011). Building on the foundation of sociological thinking, they define 'sustainability communication' as 'the task... to critically evaluate and introduce an understanding of the human-environment relationship into social discourse', and discuss sustainability communication from a system-constructivist perspective.

This paper focuses on supporting sustainability communication in product development context from a practical perspective. In this paper, the meaning of 'sustainability communication' is defined to be 'sending or receiving information that aids decision making which impacts sustainable development'. The aim of this paper is to provide an updated overview of existing practices in sustainability communication among different stakeholders in a value chain and the tools available to support these practices. The purpose is to discuss some challenges and opportunities for communicating sustainability in a value chain and answer the overarching

research question: How to improve support for sustainability communication among stakeholders in a value chain?

**Methodology** This paper draws on findings from a conceptual literature review and insights from a workshop with two involved case companies. The literature review was conducted to explore the availability of support tools in relation to how sustainability can be communicated in a value chain. The workshop gave a list of success factors for applied support tools. Together these gave a base and ideas for what the challenges and opportunities are for communicating sustainability in a value chain. In addition, this provided insights for how sustainability can be more efficiently communicated in a value chain and specifically how consumers can communicate sustainability related information to product developers to enhance development towards more sustainable solutions. Figure 1 shows the methodological flow chart for this research.



**Figure 1. Methodology adopted in this paper**

### **1.1 Literature review – Available tools that support sustainability communication**

According to Thomas and Hodges (2013), there are two general types of literature review, namely general, conceptual literature review and systemic review, while general, conceptual literature review can be further divided into two types, which are extended review and brief review. Typically, a brief conceptual literature review is about 3 to 5 pages long and provides a context or justification for the research proposed.

For this exploratory study, a brief conceptual literature review was applied by searching academic publications in the Scopus database. Scopus was chosen as a source because this is the largest curated abstract and citation database of peer-reviewed literature covering diverse fields, including science, technology, social sciences and humanities (Elsevier, 2018). The specific research questions were formulated as: ‘What are the main scientific publications regarding i) tools that support sustainability communication in a value chain and ii) challenges and opportunities reported in these publications, or that can be synthesised from these publications? The keywords used for the search were ‘communicat\*’, ‘sustainab\*’, ‘product development’ or ‘product design’, ‘value chain’ or ‘supply chain’ or ‘stakeholder’ or ‘consumer’ or ‘designer’ or ‘manufactur\*’ or ‘product developer’, and ‘tool\*’ or ‘method\*’. The search was limited to papers where the selected keywords appeared in the article title, abstract or keywords. Conference and journal articles written in English and published between January 2009 and March 2018 were included. The analysis found 49 academic references, which were purposefully sampled before a snowball analysis (Wohlin, 2014) were carried out.

The authors of this paper have read the title, abstract and keywords of all these articles and other articles found from the snowball analysis. It was found that research that focuses on

sustainability communication remains scant. For this reason, this paper also refers to and triangulates findings from grey literature such as research reports and news articles.

## **1.2 Workshop - Success factors of applied support tools**

Five persons with different responsibilities, namely sustainability management, product design and risk assessment, robust design and technology development, from two large product development and manufacturing companies took part in the workshop. These two companies had been involved in a long-term research project that aimed to support manufacturing companies to integrate and implement sustainability on strategic, tactical and operational levels. This workshop was part of the research project and served as an opportunity for the companies to learn from the practice of each other, in addition to the goal of supporting knowledge and experience sharing between industrial partners and academics. The purpose of the workshop was to explore what kind of support tools they used and why they applied them. The aim was to get a better understanding about i) which tools that were adopted by the case companies and (ii) what made them deem some of the adoptions as less successful. This workshop was also of interest as there are a lot of efforts flowing towards developing new tools and methods in research, but little usage of such is observed in industry. What are the main barriers for industry?

The workshop was divided into three blocks. The first block had the goal to: i) list support tools used in the product innovation process and ii) grade them on a scale from less successful applications to successful applications. In the second block the goal was to discuss what separates the successful applications from the unsuccessful ones, from an industry's point of view and which factors they used to make this classification. In the third block, there was a discussion on how the implementation of support tools can be improved.

## **2 Results**

### **2.1 Connected and disconnected areas of sustainability communication within a value chain**

#### *2.1.1 Communicating sustainability in a value chain*

A value chain can be pictured as a river. Product developers, e.g. suppliers, designers, manufacturers, are actors in the 'upstream' and 'midstream'. Whereas other actors involved in the post-production stage, e.g. sales units, consumers, recyclers, are in the 'downstream' (Singer & Donoso, 2008). In our literature search on the specific topic of sustainability communication, only a small number of publications were found. Most of them focus on the downstream of a value chain and discuss about how to promote sustainable consumption through marketing (e.g. Jones, Comfort, & Hillier, 2009; Solér, 2012; Visser, Gattol, & van der Helm, 2015). Sustainable product development literature has traditionally examined decision-making and value-adding activities, yet does not explicitly define sustainability communication as part of these.

#### *2.1.2 Tools that support sustainability communication in a value chain*

Sustainability communication involves communicating knowledge about sustainable development as well as storing knowledge. To empower actions, this knowledge needs a practical value and one needs to know how to make use of this knowledge. Tools, methods and instruments are essential to manage or influence the process of communication (Godemann & Michelsen, 2011).

This paper defines ‘sustainability information’ as ‘information that aids decision making which impacts sustainable development’, and broadly defines ‘sustainability communication tools’ as approaches and methodologies that can be used to support communication of sustainability information required for decision-making’. This definition includes also generic tools, methods and frameworks which may not be named or solely designed for communicating sustainability. These tools, methods, and frameworks are considered in this paper as they contribute to support sustainability communication, for example, through empowering knowledge formation and informing decision-making.

A large number of eco-design and sustainable design tools and methods have been developed in the past decades with the aim to support decision-making during product development and innovation process. Various publications have classified these tools according to different aspects, including level of applicability of the eco-design approach in product development context, functional aspects, stage of the development process and life cycle stage, tool characteristics (qualitative and quantitative), types of support for the user and level of integration in companies (Baumann et al., 2002; Navarro et al., 2005; Kortman et al., 1995; Lenox and Ehrenfeld, 1997; Janin, 2000; Byggeth and Hochschorner, 2006; Poulidikidou et al., 2014, as cited in Rossi, Germani, & Zamagni, 2016). A good example is the taxonomy of eco-design tools created by Bovea & Pérez-Belis (2012) which integrates environmental requirements into the product design process, as well as classifies methods for evaluating the environmental requirements of a product. Some of these classification schemes (e.g. Bovea & Pérez-Belis, 2012) can also act as a guide to help designers selecting the eco-design tool that best fits their case.

These eco design tools are conventionally used to prescribe design alternatives, assess environmental impacts or to compare improvement alternatives. Qualitative tools in this category typically have the format as matrices (e.g. DFE matrix, Sustainability SWOT), spider webs (e.g. Ecodesign web), checklists and guidelines (e.g. EcoDesign Pilot). Quantitative tools on the other hand are developed to measure and compare the environmental impacts of a product or service along the whole life cycle, representative examples include Life Cycle Assessment (LCA), Computer Aided Design (CAD) integrated tools, and cost accounting tools and comparing tools (e.g. LCC, LCELA) (Bovea & Pérez-Belis, 2012; Byggeth & Hochschorner, 2006; Pesonen & Horn, 2013; Rossi et al., 2016). In recent years, strategic, tactical and operational support tools have also been developed to integrate sustainability in early phases of product development, covering the whole product life-cycle, and inclusion of both quantitative and qualitative aspects (Jaghbeer et al., 2017). Adding to eco-design tools which are useful for comparing clearly specified design alternatives, these methods/ tools support also longer-term strategic decisions, cover design criteria from the ecological, social and economic dimensions of sustainability, and apply backcasting from basic principles for sustainability (Byggeth et al., 2007; Hallstedt, 2017; Ny, Hallstedt, et al., 2008; Ny, MacDonald, et al., 2008; Schöggel et al., 2014).

On a tactical level, various Design for X (DfX) approaches exist for design team to optimise specific product requirements in early design phase, such as Design for Environment (Lewis & Gertsakis, 2001), Design for Disassembly (Bogue, 2007), the Design for Remanufacturing (Kurilova-Palisaitiene et al., 2015), the Design for recovery and material recycling and the Design for Energy Efficiency approaches (Rossi et al., 2016). Gould et al. (2017) has proposed a decision support prototype to aid project teams to choose design approaches based on their relevance.

On a strategic level, government regulations and policies have been one of the main drivers that influence how producers do business and approach sustainability issues, especially in the Netherlands, Germany and Scandinavia (Lewis & Gertsakis, 2001). Sustainability reporting standards such as GRI (Global Reporting Initiative), CSR (Corporate Social Responsibility), CDP (Carbon Disclosure) were developed and used by many of the world's largest companies when disclosing their sustainability performance. Voluntary guidelines are transitioning into mandatory requirements in different parts of the world, for example stock exchanges in Hong Kong and Singapore are adding corporate responsibility disclosure requirements for listed companies (KPMG, 2017; Terry Slavin, 2018).

Alongside these 'hard' instruments (regulations & environmental policy), 'soft' instruments have been suggested and used to promote effective communication of sustainability in product development context. Two prominent examples of practice are product labelling and marketing.

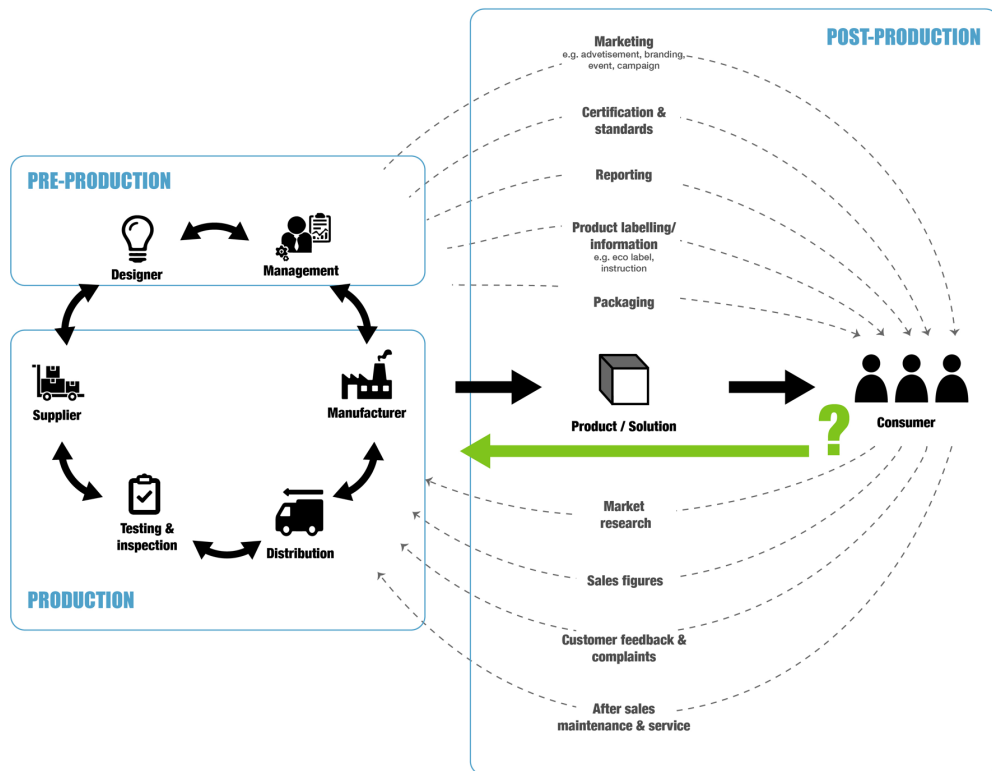
Product label is used as an information tool to identify overall, proven environmental preference of a product or service within a specific category. Amongst various eco-information provision tools, eco-labelling is recognised as the most direct practice that addresses consumer behaviour at the point of purchase (Global Ecolabelling Network, 2013; Kwok et al., 2013). Nowadays there are over 400 eco-labels or certification schemes around the world (Eco label index, 2018; Kwok, 2017), research studies however show that existing eco labels are inadequate to communicate with consumers effectively (Kwok et al., 2017), and have several deficiencies regarding supporting strategic sustainable development (Bratt et al., 2011).

Marketing is another soft instrument employed to communicate sustainability with consumers, to build trust and to improve companies' reputation. Publications have been found on discussing how to effectively promote sustainability and related performance of companies using public campaign (Töpfer & Shea, 2005), advertisement (Visser et al., 2015) and eco-branding (Selvefors et al., 2011). Social media and storytelling are noted as an emerging driving force for sustainability communicators (Yeomans, 2013, 2015). Product package design is a channel to convey sustainability information too (Garry & Harwood, 2017).

In summary, a large amount of support tools is available to inform decision-making in the upstream of a value chain (pre-production and production phases). Technical and detailed information can be analysed, both qualitatively and quantitatively, and communicated mutually between stakeholders in the compact product development team. However, relatively few tools have been developed to support the communication between product developers and stakeholders in the downstream, e.g. consumers, stock investors. After a product leaves the factory, the connection between consumer and other stakeholders in the value chain, e.g. product developers, becomes weaker. Most of the channels used to communicate with consumers allow only one-way communication that declares the sustainability strategies adopted by a company or the sustainability performance of their products.

### *2.1.3 Connecting consumers and product developers*

Figure 2 illustrates existing communication channels in a value chain with an emphasis on how to communicate sustainability with consumers. Product developers can convey a message or information to the consumer via six channels: the product/ solution itself, package design, product labelling, reporting, certification and standards, as well as other marketing strategies such as campaigns, branding and advertisement. To understand the interest and needs of consumers, existing communication channels encompass mainly market research (e.g. questionnaires), sales figures, customer feedback and complaints, and other after sales services.



**Figure 2. Communication channels in a value chain with an emphasis on how to communicate with consumers**

From the literature reviewed, we also identified several challenges faced by product developers in communicating sustainability to consumers:

- i) More communication does not guarantee better communication. Information provision may raise awareness of the problem, but does not necessarily lead to attitude or behaviour change (Töpfer & Shea, 2005). It might even have a negative impact on people's attitude towards more sustainable solutions (Godfrey & Feng, 2017). Patronising, guilt-laden or disapproving messages from governments or green groups are potentially off-putting (Töpfer & Shea, 2005). Companies that highlight eco attributes of their products risk being accused of 'greenwashing' (Dangelico & Vocalelli, 2017).
- ii) It is not easy to get the message across due to information overload (Töpfer & Shea, 2005).
- iii) Consumers are not always rational when making decisions (Töpfer & Shea, 2005).
- iv) Little information about a product is available to the product developers after the product is sold, hence it is difficult to estimate accurately the sustainability performance of a product (Kwok, 2017; Lindkvist & Sundin, 2015).
- v) Communication styles are largely affected by cultural differences. Consumer values and their priority for sustainability aspects vary across locations and cultural contexts (Töpfer & Shea, 2005).

Nevertheless, it is important to address these communication gaps for two reasons. Firstly, the collective effects of consumer purchasing behaviour are responsible for a significant amount of society's impact on the environment. Their consumption pattern can considerably influence

production patterns of manufacturers and firms (Kwok et al., 2013). Secondly, communication-to-user strategies are essential for earning commitment of users towards sustainable behaviour, hence reducing environmental impacts incurred in the usage, maintenance and disposal stage of a product life cycle (Sanyé-Mengual et al., 2014).

## 2.2 Lessons learnt from the workshop about support tools

### 2.2.1 Challenges for applying support tools

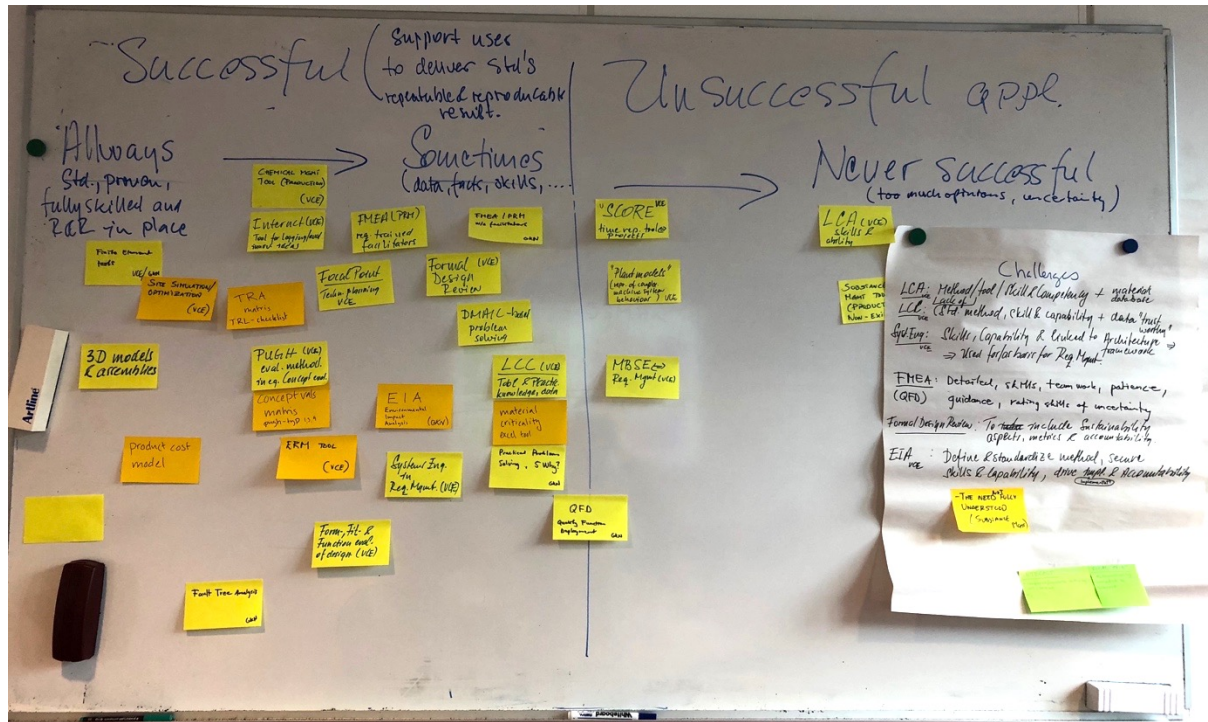


Figure 3. The participants have listed the support tools along a spectrum from ‘always successful’ to ‘never successful’

In the workshop conducted with two case companies, the participants were first asked to brainstorm the support tools they used in the product innovation process. In this first step, they listed a number of tools onto a spectrum from ‘always successful’ to ‘never successful’, see Figure 3. The participants then discussed which factors made a tool successful from an application point of view, and what defines the ‘value of a tool’, as well as the challenges for applying these support tools. The main points were:

- i) **The value of a tool depends on how it is used.** Whether a tool is a ‘good tool’ depends on the skills of the tool user and the competency of the company. For example, does the company have a comprehensive material database to support the application of LCA? As the participants stated, ‘We have suffered heavily from misusing the tools without understanding them’, ‘...it depends on how well you measured.’
- ii) **There is a need of understanding of how to connect the tools.** For example, has a company utilised the usage of a CAD model by building assemblies and coupling that with material database? This would be a useful prerequisite step before conducting LCC. Another example given by the participant was the increase in usefulness when QFD tool and PUGH matrix are linked.
- iii) **The needs are not fully understood.** The requirements for addressing the complex



sustainability challenge is not fully defined and understood by people in the companies. Company internal communication also needs to be improved.

- iv) **Qualitative tools have its limitation.** The participants pointed out concerns related to qualitative tools being not accurate nor objective enough. The results depend on the person who uses the tools, making it difficult to judge. There is a lack of standardised method which affects the trustworthiness of the tool. They thought there was a need to *'standardise methods and secure skills and capability to drive implementation and accountability'*.

### **2.3 Success factors of support tools from an industry's point of view**

When the participants were asked about the 'success factors' for sustainable design tools, three themes emerged from their discussion on the desired characteristics of these tools, namely accessibility, trustworthiness and external demand.

The participants all agreed that to encourage implementation of support tools, the tools should be accessible, which means that the tools should be *'easy to use'* and *'adaptable to different situations'* so that they could be applied to, for example, different products. The participants also looked for *'easy-to-understand communication of the results'*, for example, *'if you can see a lot of red dots, you should know that is not the solution to go for.'*

The factors that affect trustworthiness of a support tool depend on: whether they are well known, whether they are verified, validated and highly recognised, and whether it is possible to trace *'responsibility and accountability for performance and delivery'*.

The application of these tools is also driven by external demand from other stakeholders such as consumers and international standards or company standards. *'Clearly defined stakeholders and recipients would create a "pull", for example when you can see there is actually a customer demanding something from you.'* Companies tend to follow *'internationally standardised methods or company standards such as FMEA'*. *'Everybody does FMEA, it is required by customers.'*

## **3 Discussion and future works**

### **3.1 Opportunities for developing communication solutions to communicate with consumers**

To strengthen communication between consumers and product developers, we believe the two promising directions for further research would be i) to develop a deeper understanding of consumer needs on different levels and ii) to close the communication loop with consumers using digital technologies. Research on these two directions can go in parallel and complement the development of one another.

#### *3.1.1 Understanding consumer needs and perceptions*

A deeper understanding of the consumer needs shapes the communication methods and increases the chance of a shift towards more sustainable consumption pattern. Consumers' perception towards sustainability information design is an underexplored research area. How can we present sustainability information in a way that fosters understanding of it? We believe insights can be obtained for improving all the communication channels listed in Figure 3, namely product design, package design, product label design, reporting, certification and standards, and marketing strategies, if we can find answers to the following questions:

- Which aspects of sustainability performance are of interests to different segments of consumers?
- Which product attributes help in the communication of such sustainability performance? Can we harness and model consumer choice?
- How can we express these attributes through selective representation of product functions or features? E.g. eco wash setting in a dishwasher.
- How can we apply product semantics theory (Demirbilek & Sener, 2003; Monö, 1997) when designing sustainability related information that may be used for designing product, package, label or advertisement? For example, can we increase the capacity of products as a communication channel and enhance products' eco-affordance (Huang & Henry, 2009) or affordances related to other sustainable attributes? Can we use colours other than green to represent 'green design'? Can we encourage sustainable purchasing by provoking emotional responses through design?

These questions point to research directions which can potentially i) guide the development of better communication tools and ii) support sustainable product development by aligning companies' values with consumers values. These insights would also be valuable resources for designing innovative communication solutions enabled by digital technologies.

### *3.1.2 Opportunities enabled by digital technologies*

Emerging technologies are providing new opportunities for sustainability communication by completing the communication loop with feedback from consumers. The use of sensors allows sensing and tracking of product usage and user behaviour, and giving contextual data to firms. Tracking has been used by some manufacturers, mostly in the business to business sector and of expensive products such as vehicles and air jets, to obtain data for repair or insurance purposes. One example related to sustainability performance is called Life Tracking System (LTS) (Martin, 1981), which calculates the fatigue life consumption on life limited parts in for example aircraft engines. LTS enables the user to operate the engine 'as they like', since LTS calculates life consumption per component. LTS is therefore also a facilitator for pooling of spare parts between, for example, leasing customers and the operator. With the advancement in contextual technologies, e.g. the Internet-of-Things, sensing and tracking devices can potentially be embedded into a wider range of products to communicate sustainability information, for example through Eco Information Individualisation (Kwok et al., 2014, 2017).

Digital technologies also enable new shopping experiences, such as online stores, augmented and virtual reality shopping. Via digital means, a wider breadth of information can be easily displayed to consumers, e.g. visualisation of sustainability information. The purchasing behaviours can as well be monitored and stored for future use to inform decision-makings for individual user (ibid.) or product development strategies for firms.

To develop these digitalised solutions, in addition to the technological know-how and an understanding of user perception, further research is needed i) to identify relevant stakeholders and their roles as producers of data in the communication model, and ii) to investigate the ethical implications of these systems, for example on protection of sensitive data, privacy and autonomy.

## 4 Conclusion

This paper aims to provide a new perspective of sustainability communication in the context of product development with an updated overview of existing practices.

Based on findings from a conceptual literature review and insights from a workshop, this paper presents a wide range of support tools available to various stakeholders in a value chain from the perspective of sustainability communication, and reports on a list of success factors of support tools used in product innovation process from an industry's point of view.

Communication gaps in a value chain were identified, while there is room for improvement in company internal sustainability communication, the biggest gap in communicating sustainability information lies between product developers and consumers.

Challenges and opportunities in connecting the communication gaps and applying support tools are discussed. A diagram (Figure 3) is created to illustrate the existing channels to communicate with consumers as a stakeholder in a value chain. The diagram can be seen as a conceptual framework to aid the explanation of the proposed research opportunities. We delineate two major research directions which are opened up by previous research on consumers' perception and behaviour as well as advancement of digital technologies.

This paper reports on an exploratory study and the empirical results were limited by the sample size. Only two case companies from different industries and five industrial participants were involved in the workshop. Future works have been planned to collect more data from more participants and more companies from different industries.

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