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# Programme day 1 - Wednesday November 8th 2017

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## Programme day 2 - Thursday November 9th 2017

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<td>Planned obsolescence: To what extent is this phenomenon effectively tackled by the national rules set up in Belgium, France and Germany?</td>
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### 10.30 - 11.00

- COFFEE BREAK / Online DIF PLATE session: Ever-faster, Ever-shorter... Is Planned Obsolescence Real?*
  - IDE main hall
  - www.thinkdif.co

### Session 3 11.00 – 12.15

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### 12.15 - 13.45

- LUNCH / Online DIF PLATE session: Take Care to Repair*
  - IDE main hall
  - www.thinkdif.co

### Session 4 14.30 – 15.45

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### 15.45 - 16.15

- COFFEE BREAK / Online DIF PLATE session: Design for Longevity - Business as Unusual?*
  - IDE main hall
  - www.thinkdif.co

### Session 5 16.15 – 17.30

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### 17.30 – 18.15

- KEYNOTE 3: Deepali Sinha- Khetriwal
  - Product longevity: Insights from the Indian Context and Experience
  - Joost van der Grinten hall

### 18.15 - 21.30

- DINNER
  - IDE main hall

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*THE PLATE CONFERENCE LIVE.*

MODERATED BY

WALTER STAHEL

Follow live on thinkdif.co
### Programme day 3 - Friday November 10th 2017

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Design framework for emotionally durable products and services
Haines-Gadd M.(a), Chapman J.(a), Lloyd P.(b), Mason J.(b) and Aliakseyeu D.(b)
a) University of Brighton, Brighton, UK
b) Philips Lighting, Eindhoven, NL

The lighting industry is currently undergoing a systems shift; a bulb, once a consumable, is now a long-life object. However, is this how these products are regarded by consumers—as durable, potentially long-term companions within the home? Or insignificant items easily discarded, without thought? Moreover, with developments within lighting technology these products are able to provide more advanced, enhanced illumination experiences, yet this in turn has resulted in a more technologically complex object, a factor that producers and consumers must be mindful of when considering the lifespan of a product. Emotion and meaning-driven sustainability research offer a vehicle in which to explore these issues within design and the product development process. This paper presents an ‘Emotionally Durable Design Framework’ developed over the past 18 months in partnership with Philips Lighting. It defines and reveals which strategies are the most crucial when looking to extend both the emotional and physical lifetime of a given product. Our analysis relates nine themes to 38 specific strategies for Emotional Durability, and we conclude by showcasing three lighting concepts, developed using the framework which were exhibited at the University of Brighton and at Philips Lighting Headquarters in Eindhoven.

Uniquely for you: the individualised avenue for longer product lifetimes
Armellini J.(a) and Ford P.(a)
a) De Montfort University, Leicester, United Kingdom

Object customisation has historically been a regular practice as a form of self, or group-identification. A product we can identify ourselves with, is one that we keep for longer, tend to repair when it breaks and dispose of later as a result of an emotional bond with it. Such bond is strengthened when we invest time and effort customising. Consumer involvement when customising is facilitated by new technologies in design and manufacturing. For example, computer algorithms can automate customisation, meaning products are customised for consumers rather than by consumers, (namely individualisation). However, the adequate ‘amount’ of consumer interaction is still debated amongst researchers. This paper questions the consumer benefit and extent of an emotional bond with individualised products. Using a mixed-method approach, 63 participants responded to in-depth interviews while engaging with individualisation exercises. Respondents were profiled as either of two types of consumers depending on their interest in art, design and critical engagement with what they consume, namely Active Consumers (AC) and Passive Consumers (PC). Results suggest individualisation attracts PCs, showing signs of greater engagement in the process and attachment to the product than ACs. PCs welcomed the automated decisions taken by an individualisation toolkit, whilst ACs found it detrimental to the experience. It is claimed that individualisation can strengthen emotional bonds between PCs and the resulting products. The paper concludes that individualisation could offer PCs new experiences, enriching their lives, generating an emotional attachment leading to longer product lifetimes, and potentially changing consuming behaviours otherwise unlikely to be nurtured.

Exploration of the ways of empowering people in the design process through product personalization for prolonged product lifetimes
Ozan E.(a)(b) and Doğan Ç.(b)(c)
a) Yaşar University, İzmir, Turkey
b) Middle East Technical University, Ankara, Turkey
c) Carleton University, Ottawa, Canada

Product personalization has many potentials in extending product lifetimes and sustainable consumption, through strengthening the emotional bond between people and their products. In addition, production and post-use of products need to be considered in the design process to develop design solutions in line with sustainability principles. Product personalization is defined in the study as, a process during which a product’s aesthetic and functional attributes are defined, adapted or modified by the user during design, use and post-use stages of the product lifespan. To increase a product’s personal relevance to its user, during the process of personalization, user is involved as co-designer and co-maker of the product. In this study, product personalization is discussed within the local context via empowering local skills and knowledge and enabling the use of local materials and production techniques. The ways of enabling people in the design process through product personalization are explored via research through design approach. Firstly, a lighting design exploration is developed based on the design considerations emerge from the personalization and sustainability literature, and an online survey exploring people’s reasons and methods of personalization. This design exploration is further developed through three generative sessions during which the participants personalize the design exploration, record and share their experiences in the personalization process, and thus theoretical ideas are refined. The results of the study reveal that, people’s needs for personalization, their skills and motivation levels and ease of re-personalization during use phase need to be considered during design process, and these design considerations are interrelated.
1.2 Product lifetime optimization

Location: IDE Arena room
Chair: Ruud Balkenende

Considering optimal lifetimes for LED lamps: a mixed approach and policy implications
Jessika Luth Richter, Carl Dalhammar and Leena Tähkämö
a) International Institute for Industrial Environmental Economics, Lund University, Lund, Sweden
b) Lighting Unit, Department of Electrical Engineering and Automation, Aalto University, Espoo, Finland

Ecodesign policy for energy-using products so far has tended to focus on the energy efficiency requirements, but there is increasing interest in durability requirements as well. This exploratory study analyses whether and when long lifetimes are preferable when considering the trade-offs between durability and other important parameters such as costs and environmental impacts, examining the case of LED lamps. This is an interesting product group to examine because of the improving lumen efficiency of the technology as well as the increasing emphasis on lifetimes by both producers and policymakers. This research integrates both economic and environmental approaches to examine optimal lifetimes in the case of LED lamps. The first part of the research utilised an optimised least lifecycle cost (LCC) model of LED household lamps for sale in a Swedish online market, finding that optimal lifetimes were in the range of 25000-30000 hours for these lamps. However, this modelling did not consider dynamic factors such as changing prices and efficiencies. This study took the case of 800 lumen lamps to consider these factors, utilising both LCC scenarios, varying lifetime, purchase prices, energy cost and efficiency as well as LCA scenarios, varying electricity mix and lifetimes. The mixed approach demonstrates that different conclusions can be reached depending on the approach and the assumptions used. The merits and possible future improvements of these approaches for approximating optimal lifetimes of LED lamps are discussed based on preliminary findings. Lastly, the implications of the findings for further development of durability requirements and other policies are briefly discussed.

Measuring the historical change in the actual lifetimes of consumer durables
Oguchi M. and Daigo I.
a) National Institute for Environmental Studies, Tsukuba, Japan
b) The University of Tokyo, Tokyo, Japan

Product lifetime extension would contribute to establishing a circular economy and reducing the environmental impacts of mass consumption. Showing the situation of the historical change in the product lifetimes with quantitative data is needed for evaluating the contribution of product lifetime extension. The present study observed the historical change in the actual lifetimes of consumer durables in Japan by three different ways; direct observation; model calculation; simple indicator calculation. The average lifetimes of common consumer durables including home appliances, electronics, and passenger cars have been increasing in Japan over the past few decades. To evaluate the trend of the product lifetimes accurately, product lifetimes need to be observed or estimated based on actual data of discarded, collected, or in-use products. A questionnaire survey that relies on respondents’ memory would not provide precise results enough to detect the historical change in the actual product lifetimes. Calculating the ratio of the number of in-use products against the sales would generally be useful to understand the common trend in the product lifetimes over the years when the penetration of the products is saturated. The ratio could also be used as substitutes of the average of the lifetime distribution that is approximated by a statistical distribution function.

Promoting circular innovation through innovation networks: the case of cradle to cradle certified products
Schmitt J. and Hansen E.G.
a) Johannes Kepler University (JKU), Institute for Integrated Quality Design (IQD), Linz, Austria

As advancement of sustainability-oriented innovation, circular innovation addresses not only the lacking environmental challenge integration but adopts a life cycle perspective. As a product design concept for the circular economy, Cradle to Cradle promotes closed biological and technical loops. We make use of the promotor network theory for understanding how companies collaborate in an innovation network for overcoming innovation barriers and successfully developing circular products. By conducting a longitudinal in-depth case study on a cradle to cradle pioneer company in the consumables industry, we find that cradle to cradle innovators collaborate tightly on the company, supplier and linking levels. Furthermore, these companies are characterised by excellent communication structures between the various promoters in the innovation network.
1.3 Consumer and cultural perspectives

Location: Joost van der Grinten hall
Chair: Jan Schoormans

Wednesday November 8th
14.30 – 15.45

Design for sharing: libraries of things as a product-service system

Ameli, N.(a)

(a) Bochum University of Applied Sciences, Bochum, Germany

Sharing can be a way to confront ecological and social challenges. Libraries of Things offer the process of sharing in a convenient way that fits into the users’ everyday life. These Libraries offer access to a broad range of items to everyone at a low price. The items offered should be of high quality to minimize risks, to enhance the flow of the sharing process and to create as little maintenance effort and cost as possible for the library. The contradiction of offering high quality products for a relatively low price could be solved by a cooperation between manufacturers using Libraries of Things as a distribution platform. The Libraries could thus help the manufacturers to adapt their business to the circular economy.

This paper does not present a ready-made solution yet, but rather reflects upon the role of design within this area of product-service system and defines further fields of research since Lending Libraries have not yet been reflected upon from a design-angle.

Is ownership the issue? The role of responsibility in determining public acceptance of product-services systems

Cherry C.E.(a) and Pidgeon N.F.(a)

(a) Cardiff University, Cardiff, UK

Product-service systems (PSS) have been proposed as one approach towards increasing product longevity and achieving a more sustainable, low-carbon economy. Encompassing a range of different strategies - including extended producer responsibility, repair and remanufacturing, product renting and sharing schemes, and pay-per-use services - PSS often include a shift to access-based consumption, where the product is no longer owned by the consumer. We propose that the shift in ownership, and thus the location of responsibility for products, may play a role in public acceptance of these schemes. We conducted a series of four two-day workshops with members of the public (n=51), to explore this issue, using deliberative techniques to explore public perceptions of product-service systems. Two scenarios and materials were presented, describing different forms of PSS with different arrangements for ownership and responsibility for products. Overall, we found that while participants were not explicitly concerned with the lack of ownership of products under these schemes, the redistribution of responsibility that accompanied this was a serious concern. This was often rooted in a lack of trust in businesses, as well as other consumers, and led to a range of conditions being placed on participation in PSS. As such, the successful introduction of product-service systems will only be possible if careful consideration is given, not only to price and affordability, but also to deeply held values pertaining to trust and responsibility.

Room for change: impact of building-level innovations to facilitate product reuse among residents

Ordóñez I.(a), Hagy S.(b), Bard F.(b), Wahlgren L.(c) and Ringstrand B.(c)

(a) Department of Industrial and Materials Science, Chalmers University of Technology, Gothenburg, Sweden
(b) Department of Architecture and Civil Engineering, Chalmers University of Technology, Gothenburg, Sweden
(c) Industrial Ecology master program, Department of Energy and Environment, Chalmers University of Technology, Gothenburg, Sweden

This article explores the importance of building spaces in residential areas to encourage waste prevention through product reuse. First, a short review is made over five existing spaces that allow residents to leave and take products to be used again by others. Then, the initial experiences of establishing such a space in the HSB Living Lab in Gothenburg are presented to complement the review. In general, the experiences of establishing these rooms for change are positive, with users making use of the space frequently. Aspects such as location and open hours are crucial to make the change-stations convenient for residents to use. Making the space available to a large group of people is important to ensure good product flow and renewal. Even though these spaces enable product exchange between users, it is not always possible to link this exchange to a measurable effect on reduced waste generation or consumption. It is not always true that the items exchanged would have been discarded or purchased if the space to change them was not available. There is an exception when the exchanged items are food, since the food made available for others to take would have been wasted otherwise.
1.4 Business opportunities

Location: Studio 23/24
Chair: Nancy Bocken

Wednesday November 8th
14:30 – 15:45

Circular business model framework: mapping value creation architectures along the product lifecycle

Nussholz, J.(a)
a) Lund University, International Institute for Industrial Environmental Economics (IIIEE), Lund, Sweden

Circular business models are foreseen to contribute to enabling prolonged lifetimes of products and components through successive cycles of reuse, repair, remanufacturing and closing material loops. To realize economic viability and resource efficiency savings from a circular business model, early consideration and integrated planning of the product lifecycle and value creation architectures at the relevant points in the lifecycle is pivotal. However, the current frameworks for business model design have not been designed to recognize the specific opportunity points of the product lifecycle to create and capture additional value from cycling resources. They do not acknowledge that it often takes distinct value creation architectures and value propositions to capitalize on the value creation potential. To attend to this gap, this paper develops a circular business model framework that is based on the current understanding of resource efficiency strategies and systematically integrates lifecycle value management with traditional business model design thinking. Through this, the developed framework is intended to serve as guidance for circular business model development to incorporate circular principles and to capitalize on additional value from cycling resources. To explore the usefulness of the framework developed from literature, a comparative case study design with two cases of Swedish companies operating circular business models is employed. The framework proved useful to map the companies’ distinct value creation architectures that enable cycling of resources and to point to opportunity spaces for additional value creation. Suggestions for further refinement are made.

Circular added value: business model design in the circular economy

Hofmann F.(a), Marwede M.(a)(b), Nissen, N. F.(a) and Lang, K. D.(a)(b)
a) Fraunhofer Institute for Reliability and Microintegration IZM, Berlin, Germany
b) Technische Universität Berlin, Berlin, Germany

The current linear production and consumption structures, which build upon the intensive use of natural resources and cheap energy, are crucial drivers for the rapid economic development in the last sixty years. Biodiversity loss, climate change, conversion of the planet earth’s surface and resource depletion force researchers, policy-makers, business representatives, and consumers to think about alternative economic approaches and lifestyles. The circular economy concept has recently attracted increased attention from academic, political, and economic institutions. The transformation to an economy characterized by cyclical and cascading usage of natural and physical capital requires disruptive and systemic innovations. On business level integrated strategies consisting of sufficiency, consistency, and efficiency factors are needed to implement the idea of circularity in the architecture of enterprises. Business developers have to restructure value creation processes, dematerialize value propositions, rethink and demerge global supply chains or consider ecological and social aspects in their cost-benefit analyses. Currently, the most business modeling tools and methods do not consider characteristics that are crucial for designing circular business models. This study is built upon a five-step systematic literature review methodology, which focused on circular economy, conventional as well as circular business model literature. The insights gained from the extensive literature analyses were used to redefine the logic, composition, elements, and potential element attributes of the Business Model Canvas in the context of circular economy.

Classifying circular business models: a practice-based review.

Whalen K.(a)
a) International Institute of Industrial Environmental Economics, Lund University, Sweden

Business models have a crucial role to play in the transition to a circular economy. Circular business model innovation provides an arena for studying the creation of such circular business models and enables companies the possibility to identify new value creation opportunities, such as capitalizing on embedded value of products over multiple lifecycles. In comparison with the trajectory of traditional business model innovation literature, circular business model innovation is underdeveloped, and this paper aims to make a contribution to the ongoing theoretical discussion. Through review and categorization of 140 circular business model case examples, this paper makes a first attempt to verify previous literature and unify academic and industry understanding of circular business models. The findings are expected to be useful in advancing the field of circular business model innovation and assisting practitioners in the design and development of new circular business models. While the results suggest convergence around three circular business model types: ‘Access/Performance Model’, ‘Extending Product Value’, and ‘Extending Resource Value’, other previously identified circular business model types should not be discounted.
2.1 Design for product longevity

Location: Wim Crouwel room
Chair: Alan Manley

Wednesday November 8th
16.15 – 17.05

Understanding material change: design for appropriate product lifetimes

Bridgens B. and Lilley D.

a) Newcastle University, School of Engineering, Newcastle-upon-Tyne, UK
b) Loughborough University, Design School, Loughborough, UK

From the moment of purchase, pristine objects are subjected to an array of stimuli including wear, impact, heat, light, water and air which alter their tactile and aesthetic properties. Material change is often regarded as ‘damage’ or ‘degradation’, but has potential to be used as a tool to engender emotional engagement to an object and extend product lifetimes. The potential benefits, and complications, associated with material change in the context of designing for the circular economy and other sustainable product service systems is discussed. We present a framework for designers to better understand how materials change with use, and in turn how people respond to materials as they change. Key challenges are identified which must be overcome to use this framework in design practice: people’s physical interaction with objects is poorly understood, it is difficult to simulate material change, materials resources for designers do not provide information about material change, and people’s responses to aged materials depend on a complex web of interacting factors.

Transforming and prolonging design lifespans: design education cases for sustainability.

Doğan Ç.

a) Carleton University, School of Industrial Design, Ottawa, Canada
b) Middle East Technical University, Department of Industrial Design, Ankara, Turkey

This paper aims to present an approach focusing on design education for sustainability through providing two exemplary cases from third-year industrial design projects. The main themes explored in these projects involve personalization via design transformation, adaption and upgrading during design, use and post-use phases. The first project developed and facilitated at Carleton University, the School of Industrial Design mainly addresses the key theme of transformation of LED lighting from indoors to outdoors during use phase for the adaptation of design solutions for diverse tasks (e.g. mood to therapy lighting, task to outdoor lighting etc.). Second educational project developed and facilitated at METU Department of Industrial Design, aims to develop design solutions for open kitchen platform enabling transformation and upgrading during design, use and post-use phases. For each case, users are considered as active participants in the design process. The first project was undertaken individually whereas for the second one, the design students worked in teams due to the complexity of the project scope and objectives. This paper outlines the main intentions, phases and outcomes of these educational projects through providing insights and suggestions from design educators’ perspective. The illustrative student projects demonstrate some of the key principles and considerations being aimed throughout the phases of the projects. This paper also provides some future directions that can be implemented in further researches and educational projects.
2.2 Circular economy and Policy

Location: IDE Arena
Chair: David Peck

Wednesday November 8th
16.15 – 17.05

Slow fashion in retail environments: why storytelling is critical for product longevity
Matheny R.\(^{a}\) and Hernández A.\(^{b}\)

\(^{a}\) Assistant Professor, Department of Design, The Ohio State University, Columbus, Ohio, USA
\(^{b}\) MFA Candidate, Design Research and Development, The Ohio State University, Columbus, Ohio, USA

This paper presents a series of case studies examining selected slow fashion retailers’ use of storytelling elements within their respective store environments to communicate their brand’s sustainable process and mission. The term slow fashion, coined by Kate Fletcher, informs and encourages conscious consumers on responsible product sourcing and manufacturing, allowing them to feel connected to their local and global community. For slow fashion brands, fostering a strong and nurturing relationship between consumer and producer is invaluable, however few of these retailers capture that goal within their retail experience. Striving to educate and entice consumers towards more sustainable consumption, this paper presents case studies examining how storytelling elements are utilized within the retail environment to forge the consumer-producer connection.

Currently, many slow fashion retail environments lack storytelling elements, varying little from fast fashion stores. When the retail story and experience is not differentiated from those promoting mass consumption, products hold little emotional value and are disposable. This paper describes how three North American slow fashion brands (Shinola Detroit, Levi’s, and The Local by Lululemon) implemented storytelling within their store, educating consumers towards shifting their behaviors. Understanding the emotional connection between storytelling components and products reinforces slow fashion's goal by elevating products from disposable to cherished artifact. Through this analysis, designers and retailers will be provided with tools to better educate their consumers and promote a slower consumption lifestyle.

Pilling in knitwear: a clothing longevity problem beyond design
Claxton, S.\(^{a}\), Cooper, T.\(^{a}\), Goworek, H.\(^{b}\), Hill, H.\(^{a}\), McLaren, A.\(^{a}\) and Oxborrow, L.\(^{a}\)

\(^{a}\) Nottingham Trent University, Nottingham, UK
\(^{b}\) University of Leicester, Leicester, UK

The environmental impact of clothing could be reduced by extending garment lifetimes, and many clothing retailers are now exploring design for longevity as a sustainable approach. In order for products to meet durable design standards consistently, global supply chain processes must be managed and controlled to avoid quality problems and early product failure. This paper uses a single case study to explore the challenges of meeting specified durable product standards in production by tracing and observing the identification and resolution of a quality issue affecting the durability of luxury knitwear. The research demonstrates that new tests and processes could enable durable products to be produced more consistently, but also identifies the obstacles and limitations to implementing these enhanced procedures. The paper proposes that effective production management of durable clothing may be more difficult within global supply chains where differences in business culture, operational practice and knowledge exist between companies. Supply chain models that emphasise shared values, knowledge and information exchange, trust and collaboration are considered as the most effective in delivering sustainable products. It concludes by identifying a range of conflicting priorities between commercial and sustainable practice that must be addressed to achieve consistency in durable clothing production, and makes recommendations for industry and future research.
2.3 Consumer and cultural perspectives

Location: Joost van der Grinten hall
Chair: Tim Cooper

Wednesday November 8th
16.15 – 17.05

Throwaway culture as a status symbol with fashion in India

Dr. Vibhavari Kumar\(^{(a)}\)
\(a)\) NIFT, Bengaluru, India

India is a country with people of different cultural background and community. Clothing is treated differently in India. Owing to the significant social meaning held by textiles, clothing used to be rarely discarded. Instead, it used to be frequently recycled for both the domestic and global markets. But with influx of global brands with affordable, machine-made, synthetic clothing and an excess disposable income, buying in excess has become accessible to all. The research is aimed at establishing an understanding of how consumers dispose of fashion products and how to increase sustainable consumption. In addition to this, two aspects will be analysed:

1. The youth have learnt from society to ignore the value of goods once used, and hence do not possess respect for these products.
2. The people who manage to repair and not replace the product will be treated as misers and financially paralyzed, as new products are equated with status symbols.

This research examines the effects of overconsumption of clothing in India and understanding the growth of the fast fashion industry. It is also aimed at establishing an understanding of how consumers dispose fashion products and what their level of awareness about sustainability is. Research has identified the influences in increased purchase behaviour and the tendency to keep clothing for a shorter time. This is an ongoing research trying to explore and understand the current status of throwaway culture with the youth in India and to propose sustainable solutions.

Ever-faster, ever-shorter? Replacement cycles of durable goods in historical perspective

Wieser H.\(^{(a)}\)
\(a)\) Sustainable Consumption Institute and Manchester Institute of Innovation Research, Manchester, UK

Predicted by popular theories of acceleration, such as the theory of planned obsolescence and the rise of a throwaway society, the ever-faster replacement of durable goods is widely assumed in the literature. This paper confronts this assumption with long-term empirical evidence from three distinct cases – wheat seeds, automobiles, and mobile phones. The cases show that there is no dominant logic or force underlying historical changes in product durability, lifespans, and replacement cycles. Neither are such changes entirely unpredictable: There are clear patterns where these phenomena go up or down for sustained periods of time. The observed patterns in replacement cycles call for an empirically grounded theory that can explain both periods of acceleration and deceleration and connect durable goods replacement decision-making with developments at the aggregate level.
2.4 Business opportunities

Location: Studio 23/24
Chair: Paul Nieuwenhuis

Wednesday November 8th
16.15 – 17.05

Sustainable business model experimentation practices: evidence from three start-ups

Schuit C.S.C\(^{(a)}\), Baldassarre, B.\(^{(b)}\) and Bocken, N.\(^{(c)}\)
\(\text{a) Innoboost, Amsterdam, the Netherlands}
\(\text{b) THANKS, Amsterdam, the Netherlands}
\(\text{c) Industrial Design Engineering, Delft University of Technology, Delft, the Netherlands}

With a growing world population, resource use, and the effects of climate change, it is apparent that our current 'take-make-dispose' economy cannot be sustained. Sustainable business model innovation integrates sustainability objectives into business models to achieve a positive impact on society and/or the environment in combination with pursuing profit. Experimentation capabilities are essential for implementation, but established companies struggle with execution. Start-ups are more acquainted with a trial and error approach in which assumptions are gradually validated or adapted to market needs. To contribute to the shift towards sustainable business models, this paper explores how start-ups develop sustainable business model experiments and which elements of the sustainable business model canvas are tested through experimentation. Three start-ups were followed in their experimentation journey to develop profitable sustainable business models. Results indicate that 1) experiments always concerned the value proposition and another building block of the business model with a high-risk profile 2) start-ups use easy accessible resources to execute experiments in a fast paced and iterative manner 3) decisions of continuation of business model ideas were based on the outcomes of experiments in relation to the purpose of the company. In addition, this paper provides examples of experimentation practices of these start-ups to give hands-on examples how sustainable business model experimentation can be developed.

Challenges and support for scaling up upcycling businesses in the UK: insights from small-business entrepreneurs

Sung K.\(^{(a)}\), Cooper T.\(^{(a)}\), Ramanathan U.\(^{(b)}\) and Singh J.\(^{(a)}\)
\(\text{a) School of Architecture, Design and the Built Environment, Nottingham Trent University, Nottingham, UK}
\(\text{b) Nottingham Business School, Nottingham Trent University, Nottingham, UK}

Upcycling is the creation or modification of a product from used materials, components and products which is of equal or higher quality or value than the compositional elements. Within the context of increased product longevity, it enables a reduction in the use of raw materials by extending the lifetime of used materials, components and products, thereby increasing material efficiency and reducing industrial energy consumption. If scaled up to a considerable level through appropriate interventions, upcycling could, in theory, contribute significantly to preventing environmental harm. In particular, upcycling-based businesses have been identified as one of sustainable alternatives to prevailing business models that are based on unrestrained access to virgin materials, in contrast with the circular economy. Previous research regarding upcycling has focused mostly on fashion and textiles and highlighted the potential of upcycling businesses, providing sector-specific suggestions for expansion beyond their currently niche status. There is a critical knowledge gap concerning ways of achieving the full potential of upcycling-based businesses across the whole economy. This paper therefore provides results from a study on the challenges that upcycling entrepreneurs face when attempting to scale up and how to overcome them, based on an exploratory workshop with 12 British upcycling entrepreneurs. It identifies the key challenges faced by upcycling businesses and presents a mapping of the systemic support required for overcoming them, with potential actors.
Workshop 1
Location: IDE Arena

Working with two theoretical perspectives from consumer studies to research circular business models and product service systems
Maurizio Catulli\textsuperscript{(a)(b)}, Matthew Cook\textsuperscript{(a)} and Stephen Potter\textsuperscript{(a)}
\textit{a) The Open University, Milton Keynes, UK}
\textit{b) University of Hertfordshire, Hatfield, UK}

This workshop is aimed at researchers interested in circular business models, particularly Product Service Systems (PSS) consumption. The workshop addresses the challenges of researching consumer relationships with PSS using different approaches from consumer studies: consumer culture theory and practice theory. Researchers will be interested and able to contribute if they are interested in PSS consumption (in the context of circular economies) and in the challenges of operationalising research perspectives in either a pluralistic or integrated fashion.

Workshop 2
Location: Wim Crouwel room

Options for lifetime labeling: design, scope and consumer interfaces
Dalhammar C.\textsuperscript{(a)} and Richter J.L.\textsuperscript{(a)}
\textit{a) Lund University, Lund, Sweden}

LABELING LIFETIME: BUT HOW? There is agreement among many EU member states that consumers should have access to information about the product lifetime at the time of purchase. However, designing such an information scheme will be very difficult in practice. In this session we will outline and discuss the main issues and ask for your input on how to resolve them. Welcome!

Workshop 3
Location: Studio 6

Electronic textiles and product lifetimes: how can multi-disciplinary design strategies for product longevity be placed at the heart of the wearables industry?
McLaren A., Hardy D.A. and Hughes-Riley T.
\textit{a) Nottingham Trent University, Nottingham, United Kingdom}

Can smarte-textiles be sustainable? This workshop will include insights from teardown of a smart garment, giving the opportunity to find out what is inside an e-textile and discuss the products that are being developed as part of this booming market. The discrepancies in lifetimes of textiles, electronics and other components will be explored with an expert panel, along with discussion of methods of extending product lifetimes, recycling and disposing of smart fabrics.

Workshop 4
Location: Studio 23/24

Engaging consumers in product lifetime extension
Heller B.\textsuperscript{(a)}
\textit{a) UN Environment}

Debate is on the rise around the durability of certain products, and concerns about a growing ‘throwaway’ culture in many societies around the globe. At the same time, new consumption trends and models, such as product repair portals or collaborative consumption, offer potential for sustainability and consumer empowerment. Exploring behavioral insights, this session will discuss how to engage consumers in product lifetime extension, with a view to showcase good practices for replication and potentially pursue new ideas in the framework of the 10YFP Consumer Information Programme.

Workshop 5
Location: Studio 13

Exploring cherishability as a future model: exploring textile materials, hand skills and personal response
Mclauchlan S.\textsuperscript{(a)}
\textit{a) School of Design, Edinburgh University, Edinburgh, Scotland}

A practical workshop exploring and experiencing how materials and technique influence our personal response to what we cherish. An opportunity to explore theory via hand skills creating some valuable evidence. This workshop is an opportunity to ‘play’ with textile materials.
**Workshop 6**
Location: Wim Crouwel room

**A research agenda for expected product lifetimes: a review of knowledge and priorities for future research**

Gnanapragasam A. (a), Oguchi M. (b), Wieser H. (c), Cole C. (a), Rodrigues A. (a), McLaren A. (a) and Cooper T. (a)

a) Nottingham Trent University, Nottingham, UK
b) National Institute for Environmental Studies, Tsukuba, Japan
c) University of Manchester, Manchester, UK

How long do consumers around the world expect their products to last? How do researchers evaluate consumer expectations of product lifetimes across the globe? Why might it be important for academics to work together in this area in order to further efforts towards a circular economy? This seminar will bring together researchers of expected product lifetimes to review the current state of knowledge and set future priorities for international collaboration.

**Workshop 7**
Location: Studio 6

**Consumer intervention mapping across the product lifecycle**

Sheldrick L. (a), Sinclair M. (b), Moreno M. (c), Dewberry E. (d) and Makatsoris H. (e)

a) Imperial College London, London, UK
b) Loughborough University, Loughborough, UK
c) Cranfield University, Cranfield, UK
d) The Open University, Milton Keynes, UK

d) The Open University, Milton Keynes, UK

d) The Open University, Milton Keynes, UK

This workshop will seek to work to envisage possible futures where people are engaged in the design of the products they use, and resource efficient product lifecycles can be incorporated within more localised and responsive structures of manufacturing and product adaptation. We will present four possible future scenarios, and together participants will use our ‘Customer Interaction Maps’ to generate new concepts of how people can be incorporated into the product whole life cycle.

**Workshop 8**
Location: Studio 23/24

**Generation starships: exploring a space of material scarcity through fiction and speculative design**

Han S. (a) and Atkinson D. (b)

a) Manchester Metropolitan University, Manchester, UK
b) London College of Fashion, London, UK

This workshop will help develop your creative responses to a fictional circular economy challenge. As a passenger journeying for decades, centuries or possibly millennia to find Earth-like exoplanets, how would you efficiently utilise limited resources within a closed environment, to meet material and cultural demands for clothing and textile products? How will you maintain product quality? How will your relationships to products develop? What forms will socio-cultural displays, product aesthetics and your fashioned identity take?

Participants are encouraged to bring their own images, books, products, materials and garments, and to wear any outfits or items they feel would be pertinent as a design provocation discussion point as part of the workshop.

**Workshop 9**
Location: Studio 13

**Interdisciplinary approaches: teaching clothing longevity strategies across educational disciplines**

Mclaren A. (a), Claxton S. (a), Hill H. (a), Cooper T. (a), Oxborrow L. (a) and Goworek H. (a)

a) Nottingham Trent University, Nottingham, United Kingdom

How do we encourage and enable interdisciplinary systems thinking approaches to sustainable fashion design and business education? In this workshop, participants will trial and contribute to the development of a toolkit—The Clothing Durability Dozen—aimed at enabling students to collaborate and learn about sustainable fashion across disciplines, with the aim of creating a better understanding of the roles that different departments can play in placing design strategies for clothing longevity at the heart of the clothing industry.

**Workshop 10**
Location: IDE Arena

**Planned obsolescence: to what extent is this phenomenon effectively tackled by the national rules set up in Belgium, France and Germany?**

Michel A. (a)

a) Faculty of Law, KU Leuven, Belgium

In addition to EU rules and their corresponding national implementing measures, Member States have devoted efforts to promote product durability and sustainability. Nevertheless, it is questioned whether these national rules effectively combat and prevent the phenomenon of planned obsolescence, i.e. whether they respect and conciliate in a balanced way all the interests at stake (consumers, producers and environment). Through a poll and interactive discussions, this workshop aims at providing an answer to this central question.
3.1 Design for product longevity
Location: Wim Crouwel room
Chair: Masahiro Oguchi
Thursday November 9th
11.00 – 12.15

Playing for time: seven practice-led workshop tools for making design decisions to extend the life of fashion textile materials and products
Earley R. and Goldsworthy K.
(a) University of the Arts London, UK
Since 2011, the authors have been developing creative and playful sustainable design workshop tools to understand, develop and share knowledge and ideas with other designers. These tools originated through practice-led research methods, involving prototyping, to explore and consolidate research theories. By translating design strategies into both realised artefacts and tools for engaging others through design, the authors have continuously transformed practice and theory in the field. More recently the theory has become focused on the starting point of circular models for design, in particular, designing for lifecycle speeds. This paper discusses some of the tools used for exploring ‘product longevity’ and ‘circular’, resulting in further insights for future design, including the current understanding of ‘longevity’ as both a product and a material consideration, with two seemingly opposed strategies. The authors research groups’ primary methodological approach is through designing and making textile/fashion artifacts to generate new theory; in order to share this approach and support others outside of the group to use making as a key research method they often design and facilitate workshops and create tools, which are then shared via the project website. In this paper tools developed specifically to design to extend the life of a fashion textile product are discussed and the creative outcomes generated are presented. The playful tools generated playful ideas and by reflecting via field notes on these industry workshop outputs the authors here offer a set of tools to support designing sustainable and circular textiles for long life.

Risk & Race: Creation of a finance-focused circular economy serious game.
Whalen K.
(a)(b) University of the Arts London, UK
(b) In the Loop Games, Netherlands
As the topic of circular economy gains increasing popularity, a growing number of serious games and tools have been developed to assist in educating about circular business models. A review of these existing games suggests a lack of emphasis on business operations and financial implications behind circular business model investment decisions. In contrast, recent academic literature suggests the economic implications of adopting circular business models should be stressed, given potential financial differences between circular business models and linear business models. This paper introduces Risk & Race, a serious game developed to assist in bridging this gap between literature and practice by illustrating the financial drivers and barriers to implementing circular business models in practice. Initial findings from testing with students suggest the game succeeds as a support tool for modeling business operations and explaining the financial side of circular business models.

Sustainability cards: design for longevity
Hasling, K.M. and Ræbild, U.
(a) Design School Kolding, Kolding, Denmark
Product longevity is considered widely as a relevant strategic approach, amongst many, within the field of sustainability. Yet, how to design for increased product lifetime may not be so obvious for practitioners. The complexity of the surrounding issues can constitute a barrier for designers and companies, in terms of adopting and implementing the approach in the design process. This paper explores whether, and possibly how, the ‘design card’ format (i.e. method card or alike), can be a way to support dissemination, application and communication of knowledge related to the notion of product longevity for designers and other stakeholders in the design process. The paper is based on a development project carried out in the Autumn 2017, within a larger research and collaboration project between raw fur manufacturer Kopenhagen Fur and Design School Kolding investigating sustainability perspectives. The paper describes the development of a deck of sustainability cards aiming for product longevity and presents the final deck. Furthermore, the paper contributes with insights on how designers may apply design cards in the design process and how this practice can further sustainable considerations and strategies in terms of product longevity. As the paper builds on a single case study and is situated within a single discipline (fashion and apparel), the outcome should be considered as tentative indications of future potential.
3.2 Product lifetime optimization

On the meaningfulness of data in product design for lifetime optimization

Fiore E. (a) and Bourgeois J. (b)

a) Department of Architecture and Design, Politecnico di Torino, Turin, Italy
b) Department of Design Engineering, Delft University of Technology, Delft, The Netherlands

Planned obsolescence is generally considered as a negative business strategy that induces replacement needs and affects attachment dynamics, as opposed to the goal of elongating product lifetime. At the present, however, an early replacement of long-lasting products is preferred in at least two cases which can be addressed during the design stage i.e. when the cost of maintaining is higher than product benefits and when there are environmental reasons to replace obsolete products. Furthermore, designing meaningful products that help the user in his/her daily activities, while addressing environmental issues, could help affecting attachment even in standardized and utilitarian products, such as home appliances. In this study, the holistic view and the management of the complexity of Systemic Design, combined with the use of the IoT technologies are proposed using the refrigerator as a case study. Acquiring information is considered as a tool for product innovation; the data is divided into (i) static data, related to the product and (ii) dynamic data, which derive from the context of use and interaction with users. The latter can be acquired by investigating the object’s daily use and environment, with data acquisition through quantitative tools (sensors) and qualitative ones (feedback, questionnaires, interviews). IoT and data retrieval open a variety of possibilities in monitoring, accessing more precise knowledge of products and households useful for design purposes. This paper seeks to demonstrate how IoT can support and trigger a design transition towards more durable products and components, by focusing on sustainability and simplifying people's lives in daily actions.

Repair vs. replacement: what is the best alternative for household small electric and electronic equipment?

Bovea M.D. (a), Ibáñez-Forés, V. (a), Pérez-Belis, V. (a)

a) Department of Mechanical Engineering & Construction, Universitat Jaume I, Castellón, Spain

This study presents a methodology designed for selecting, from an environmental point of view, the best end-of-life strategy for electric and electronic equipment which breaks before the end of its life span. For that, the environmental impact of the life cycle of the equipment is evaluated considering two alternative end-of-life strategies: repair & reuse or replacement. The Life Cycle Assessment methodology is applied to evaluate the environmental performance of each scenario, taking ReCiPe as end-point impact assessment method. The methodology is applied to a representative sample of nine categories of small household electrical and electronic equipment, considering different types of repair for each category and the replacement of the equipment in different years of its lifespan. For all the analyzed categories, the repair & reuse strategy generally proved environmentally better performance than replacement. However for some types of repairs, e.g., those related to engines or printed circuit boards, if they occur in later product life cycle stages, it is better to replace equipment as the environmental impact from their repair operations is so high than it does not compensate prolonging the years of useful life obtained.

How modularity of electronic functions can lead to longer product lifetimes.

Nissen N. F. (a), Schischke K. (a), Proske M. (b), Ballester M. (c) and Lang K.-D. (a)

a) Fraunhofer IZM, Berlin, Germany
b) Technische Universität Berlin, Berlin, Germany
b) Fairphone B.V., Amsterdam, the Netherlands

Although electronics are not the cause of the biggest environmental concerns in absolute terms, they receive special attention, because the impact per unit can be very high even for small devices and because electronics pervade our everyday life and our business life. Since a huge amount of resources is embedded in the products as they are delivered to the market, extending the product use time is for many product categories a primary ecodesign improvement option. Yet there are many obstacles to simply making products more robust and longer lasting – and to adapt the user behaviour and the business models to these potentially higher priced products. It is therefore worthwhile to rethink product concepts for the circular economy by using modularity to achieve better repair, better upgradability and in general a better customisation to the changing needs along a chain of ownership.
The influence of information about prior use on consumers’ evaluations of refurbished electronics

Mugge R.\textsuperscript{[a]}, de Jong W., Person O.\textsuperscript{[b]}, and Hultink E. J.\textsuperscript{[a]}
\textsuperscript{a) Delft University of Technology, Delft, the Netherlands
\textsuperscript{b) Aalto University, Helsinki, Finland}

Refurbishment – the process of collecting used products, assessing their condition, and replacing and/or upgrading parts in order to resell them to other consumers – is increasingly seen as both economically and environmentally advantageous. The present research investigates in an experimental study and with qualitative post-hoc interviews how information about prior use – offered in either a visual (signs of wear and tear) or verbal (textual description) form – influences consumers’ evaluations of refurbished products. The findings show that providing consumers with information about the prior use of refurbished electronics does not have a univocal effect on consumers’ evaluations of such products. Visual information about prior use, in terms of signs of wear and tear, has a negative effect on consumers’ evaluations of refurbished electronics. Furthermore, presenting consumers with verbal information on prior use can negatively affect consumers’ evaluations of a refurbished if no signs of wear and tear are present because it confuses consumers. If signs of wear and tear are present, verbal information about prior use will not influence consumers’ evaluations.

Dimensions of sustainable behaviour in a circular economy context

Daae J.\textsuperscript{[a(b)]}, Chamberlin L.\textsuperscript{[c]} and Boks C.\textsuperscript{[c]}
\textsuperscript{a) Department of Product Design, Oslo and Akershus University College of Applied Sciences (HiOA), Oslo, Norway
\textsuperscript{b) Bergfald Environmental Consultants, Oslo, Norway
\textsuperscript{c) Department of Design, Norwegian University of Science and Technology (NTNU), Trondheim, Norway.}

Although Design for Sustainable Behaviour research has seen increasing attention over the last decade, limited attention has been directed towards behaviours relevant for a circular economy. To investigate this shortcoming, this paper collected empirical examples that reflect where these two research fields meet. The result of this analysis is presented as a grid consisting of nine dimensions of behaviour change (control, obtrusiveness, timing, exposure, meaning, importance, direction, encouragement and empathy) and four goals for circular economy (maintenance, reuse, refurbishment and recycling). The collection of behaviour change principles shows that examples for almost all combinations exist, with least being identified for refurbishment and most for recycling. This insight does not only give an indication on where attention has been directed previously, but also suggests areas where there may be a need for further development of behaviour principles. The overview of examples of behaviour changing principles related to circular economy may also foster inspiration among practitioners both within Design for Sustainable Behaviour and circular economy.

What’s hot what’s not: the social construction of product obsolescence and its relevance for strategies to increase functionality

Jaeger-Erben, Melanie\textsuperscript{[a]} and Proske, Marina\textsuperscript{[b]}
\textsuperscript{a) Center for Technology and Society, TU Berlin, Germany
\textsuperscript{b) Environmental and Reliability Engineering, TU Berlin, Germany}

“Is it ethical to deny our products what we wish ourselves: A long live?” is one of the major questions the German documentary “Do mixers go to heaven?” from 2016 asks. The star of this documentary is the RG28, a mixer once produced by a former GDR electronic factory, which became famous for its robustness and longevity. The factory didn’t survive the Wende in 1989 but the mixers are still available on internet platforms and un-junk-shops, some spare parts for the easy-to-repair mixer are still produced. Although it appears as a somewhat pathetic humanization of objects at a first glimpse, it makes an important point: Product lifetimes are more than a property of objects, a rationally calculated number that is inscribed in a product’s design. The lifetimes of things made, used and disposed by humans can also be seen as an important characteristic of a given material culture and is rooted in current human-object relationships. This paper discusses both aspects – material culture and human-object relationship – with relation to the highly contested term obsolescence. Starting with the observation that obsolescence received most public attention in times of crisis, we report results of an analysis of current media discourses. Subsequently we present an alternative praxeological approach to obsolescence than the usual rational choice related explanations. The closing section discusses opportunities to increase a product’s “affordance” to be kept alive longer.
3.4 Business opportunities

Business experiments as an approach to drive sustainable consumption: the case of HOMIE

Bocken, N.M.P.\textsuperscript{(a)(b)}, Bom, C.A.\textsuperscript{(b)}, Lemstra, H.J.\textsuperscript{(b)}
\textit{a) Industrial Design Engineering, Delft University of Technology, Delft, the Netherlands}
\textit{b) HOMIE B.V., Julianalaan 67a, 2628 BC Delft, The Netherlands}

Sustainable business models and in particular Product Service Systems (PSS) are often linked to increased environmental performance. However, such benefits can only be achieved when the business model is intentionally set up to deliver those positive impacts, by incorporating issues around efficiency gains, through-life issues and sustainable consumption patterns into the design. Several start-ups are emerging who are pursuing new PSS business models but sustainability impacts are not always measured. Also, knowledge on how to iterate new sustainable business models through experimentation is sparse. This paper explores how companies can contribute to sustainable consumption through experimentation with new business models and in particular ‘pay per use’ business models. We apply knowledge on influencing consumer behaviour to develop business experiments. This paper includes an in-depth case study of HOMIE, a start-up pursuing a pay per use business model for home appliances (washing machines). An experimentation roadmap is presented for HOMIE. Effects of a range of experiments are included, such as providing information and social comparison. The pay per use business model was found to have the potential to help stimulate sustainable consumption patterns. For example, social comparison could be used effectively to stimulate more sustainable laundry behaviour. Future research could focus on mapping ideal sequences of experiments to achieve the greatest levels of sustainability impacts, and investigating other sustainable business models such as renting and sharing using the experimentation approach.

Will durability be a characteristic of future cars?

Nieuwenhuis P.\textsuperscript{(a)(b)}
\textit{a) Centre for Automotive Industry Research, Cardiff Business School, Cardiff University, Cardiff, Wales, UK}
\textit{b) Sustainable Places Research Institute, Cardiff University, Cardiff, Wales, UK}

The car industry believes it has already done a lot to meet the sustainability agenda. While there has been considerable progress in terms of reductions in toxic emissions, as well as greenhouse gas emissions, they are still very far from being sustainable either as an industry or in terms of the products they make. This point was made by Stuart Hart in 1997 (Hart, 1997), and despite progress since then, the same still holds today. Progress so far has been along an ‘eco-efficiency’ trajectory – i.e. doing the same thing we have been doing, but more efficiently. In reality, we need to stop doing what we have been doing and work out an alternative means of achieving what we are actually trying to achieve – motorised personal mobility with optimum enjoyment, comfort and safety levels. We need to do things differently, in other words.

It is clear that we are at the start of a technological transition from IC to EV powertrain technology in cars and light commercial vehicles. This brings with it a shift in the lifetime carbon impact of the vehicle from the use to the manufacturing and recycling phase (Ricardo 2011; Hawkins et al. 2012). This would suggest a longer product lifespan would be desirable for EVs. It has also been suggested that the current or imminent transition in the personal transport system involves not only a technological transition from IC to EV, but also a transition in ownership patterns from private ownership of cars to various types of PSS, such as car clubs, leasing models, etc. (Marletto 2014). Does this mean that we will witness a further alienation of the user from the product? If so, would this result in an even lower value being placed on the product by the user than we have already seen so far? Alternatively, would such a move instead create an incentive on the part of the new owner, i.e. the provider of the PSS, to regard the vehicle as an asset that needs to be valued for its ability to enable the business to operate, the ‘P’ in the PSS.

A double diffusion of innovations: the case of electric automobility product service system.

Catulli M.\textsuperscript{(a)}, Cook, M.\textsuperscript{(a)} and Potter, S.\textsuperscript{(a)}
\textit{a) Department of Engineering and Innovation, Open University, Walton Hall, Milton Keynes, UK}

This paper explores the double diffusion of an electric vehicle Product Service System (PSS). The research is based on a case study of a use orientated PSS run by UK-based e-car club.

The double diffusion involves consumers being confronted with electric vehicles (EV) – a technical innovation, accessed through a car club – a PSS sociotechnical innovation. The paper explores the intertwining of these two innovations.

Using Practice Theory, the paper concentrates on meanings that users associate, or find lacking, in performing automobility through an EV car club. For an EV mobility PSS to diffuse, it is necessary to disassociate it from meanings of poor availability, range anxiety and concern about location of charging facilities and associate it with positive meanings of freedom, thrift, altruism and environmental protection. The offer of additional service through links with mobile phone apps could facilitate diffusion. These meanings appear to have stronger resonance among certain segments of car users than others, which suggest that insights offered by Practice Theory need to be complemented by other research perspectives to explore characteristics of individual users.
4.1 Design for product longevity

Sustainable fashion tailoring: an approach for creating a heightened emotional attachment to garment apparel at undergraduate level, through pedagogy, story telling, digital technologies and traditional craftsmanship

Morrish D.(a) and Pal R.(b)
a) Sheffield Hallam University, Sheffield, England
b) Swedish School of Textiles, University of Borås, Borås, Sweden

Higher Education undergraduate programmes of study have a responsibility to educate learners within their discipline, bridging the gap between education and the real world. Never before has it been so important to equip learners who can adapt and accommodate change within their practice responding to external socio-economic, cultural, political and environmental concerns. With sustainability a key global concern, it is imperative that educational institutions educate its learners to help change the direction of a throwaway and environmentally unsustainable industry. "Fast Fashion Is the Second Dirtiest Industry in the World, Next to Big Oil" Sweeny (2015)

This paper is a case study of second year undergraduate learners on a UK fashion design degree programme who were challenged by the luxury brand Ted Baker to design a collection of men's formal wear suits, combining sports detailing with traditional tailoring for the brands DNA and customer demographic. The primary argument of this paper arises from the need to further develop the theoretical aspect of the design process to improve learners understanding of the key principles of design, consumer behavior and basic human psychology. The inquiry adopted a practice based approach gathering data from workshop/seminar observations, client feedback and assessment of student 2D and 3D outcomes.

Learners were exposed to the technical challenges of tailoring and encouraged to embrace and experiment with CAD/CAM technologies and unorthodox design and pattern cutting methodologies as well as traditional methodologies in order to affectively communicate a considered narrative. While assessment of outcomes indicate an improvement to the depth of thinking and creative application of story telling by the majority of learners, surface learning was still evidenced as a concern, encouraging further analysis of future pedagogy approaches.

Conditional garment design for longevity

Gwilt A.(a) and Pal R.(b)
a) Art & Design Research Centre, Sheffield Hallam University, Sheffield, UK
b) Swedish School of Textiles, University of Borås, Borås, Sweden

In the clothing sector, approaches to design for longevity can provide the “…single largest opportunity to reduce the carbon, water and waste footprints of the clothing in the UK” (WRAP, 2013a). Although an emphasis lies on slowing consumption, the types of design-led approaches that can be used to achieve this goal are considerably varied yet sparingly used by the mainstream fashion industry. In light of the growth of a circular economy, the challenge facing the fashion industry is to adapt the existing product design and development model and explore a fashion system where other, more diverse design approaches can prosper. Thus, this paper attempts to contribute to this debate and further highlight factors that need to be considered by fashion companies when developing garments designed for longevity.

Through a range of novel design principles/methods, underpinning modularity and incremental garment design/construction in this paper we demonstrate how designers may begin to envisage garments as items designed for longevity. The experimental work carried out here is part of a larger initiative, Re:Textile in Sweden (Retextile, 2017). In the experiments conducted we demonstrate the power of various garment design conditions intended to synthesize a change towards garment longevity. Together with highlights of the key processes and basic design principles underpinning these design-led approaches, the experimental work also specifies how and where they contribute in achieving the aims of designing in a circular economy. The findings also highlight the opportunities for improving the redesignability of the garment in its active use life as set by the original design conditions laid in light of design for longevity.

Improvement design in portuguese wool lifecycle: ecological yarn collection

Morais, C.(a) and Barragão, V.(b)
a) CIAUD, Faculty of Architecture, University of Lisbon, Portugal
b) Faculty of Architecture, University of Lisbon, Portugal

Wool is a light, comfortable, and durable fibre that forms a protective covering against both heat and cold. In Portugal, raising sheep, wool collection and production of yarn has been a domestic craft work for centuries, concentrated mainly in the East and South of the country, particularly in Serra da Estrela and Alentejo. The sorting and storage of wool is done by companies associated to “Merino” wool producers, however, this type of wool is only a small percentage of the country’s total production. The country has many other varieties of wool but these may end up burned, which generating toxic waste, if they do not make it to the market to be sold. This paper presents a general approach, discussing the possibility to recover these remaining wool fibres that did not sell, through the manufacturing of artisanal and ecological yarn. This aims to promote animal welfare and ancestral spinning techniques and processes, practices from a long-nurtured Portuguese textile heritage. The practical experiment and study express concern over fast fashion, presenting points of interest for a slow product system, which may provide for a circular life cycle for products. The creator of eco-friendly yarns also represents an important role as a mediator and an interventionist in the garments design, thus creating value for the products and increasing material lifespan.
4.2 Circular economy and policy

Location: IDE Arena
Chair: Sharon Prendeville

Thursday November 9th
14.30 – 15.45

“Crafting the waste” as a stimulus to collaborative learning and collective production: an example from Turkey
Atalay, D.(a)
a) Beykent University, Textile and Fashion Design Department, Istanbul, Turkey

Craft, playing a significant role in the story of sustainable fashion design, is a deep-rooted tradition in Turkish society. Besides the symbolic meaning of the hand-made, by generating emotional bounds it hinders consumers from throwing their products away (Clark, 2008). Therefore it is used as a design strategy to eliminate waste. Moreover, many of the Turkish craft techniques are based primarily on the reuse of the old and wasted materials. Over the last few years, many women-centred initiatives and cooperatives started to value craft and labour-intensive production outside of a home. However, many traditional craft techniques are on the verge of extinction since the Turkish youth is not willing to learn them. It is an uneasy fact that in design education, craft-based practices, and collaborative work are generally ostracized. However, craft based practices promise to be valuable methods for the development of sustainable design in developing countries. Regarding the current situation of craft and design education, the aim of this research is to explore how design education can be re-contextualized in order to generate social change, stimulate collective production and question the hierarchies in the existing system. The main objective of the study is to generate alternative ways of learning and designing through craft and upcycling. Therefore; in addition to the literature review, a case study has been conducted. As part of the case study, a small group of volunteer Textile and Fashion Design students were asked to collaborate with a women's cooperative and create a collection of accessories collaboratively.

Towards a typology of waste in fashion practice: an Australian perspective
Payne A.(a) and Binotto C.(b)
a) Queensland University of Technology, Brisbane, Australia
b) Independent scholar, Sydney, Australia

Waste in fashion is a material problem as well as a cultural condition. In this paper we offer a cultural perspective on waste transformation in fashion practices: what happens to waste, rather than where it goes. We propose states of transformation of waste: disguise, elevation and enchantment. These states are not a hierarchy but rather a typology to consider the kinds of material and cultural transformations that waste undergoes when revalorised through fashion practice. The study centres on the Australian context, and seeks to examine the ways in which Australian fashion retailers, designers, and community groups are engaging with clothing and textile waste. We identified forty-seven initiatives and explored their approaches to waste transformation. Through selected vignettes, this paper examines both the material processes and symbolic meaning behind the approach and its messaging, and offers reflections on the ideas of waste that emerge. Selected examples include large fashion retailers, independent and experimental fashion practitioners, and grassroots campaigns by local charities. Looking beyond the practical approaches to waste management, such 'reduce, reuse, recycle,' or the waste hierarchy, we explore ways in which these practices may ‘disguise' waste, 'elevate' waste, or 'enchant' waste. Through this analysis, we argue for a perception of waste beyond that of inevitable by-product of the industry, towards waste recast as a potent force of loss and renewal.

Impact on resource intensity from consumer disposition: relationship with product lifetime and disposal.
Yamamoto H.(a) and Murakami S.(a)
a) Department of Systems Innovation: The University of Tokyo, Tokyo, Japan

Sustainable resource use is a key challenge for our global society, and consumers are certainly responsible for making our resource use more efficient, e.g. by longer use of products and handing their End-of-Life products (EoLs) in to appropriate recyclers. Product lifetime can be one essential sustainable consumption intensity indicator to measure how much value the consumer extracts from a product. We have investigated the relationship between lifetime of electrical and electronic equipment (EEE) as well as EoLs destinations and consumer dispositions through a quantitative survey questionnaire amongst consumers in Japan. We identified three dispositions; well-organized, trend-conscious and community participation. All of these dispositions had non-negligible influences on both lifetime and EoLs destinations. The consumer groups with bigger potentials to improve resource intensity in terms of lifetime and of EoLs destinations were different. Policy makers can set two different policies to two different groups, and both policies will have positive impacts independently.
Object therapy: critical design and methodologies of human research in transformative repair

Keulemans G.\(^{a}\), Rubenis N.\(^{b}\), Marks A.\(^{c}\)
\(^{a}\) University of New South Wales, Sydney, Australia
\(^{b}\) Australian National University, Canberra, Australia
\(^{c}\) Independent Social Entrepreneur, Sydney, Australia

This paper outlines the framework, development, methodologies and objectives of 'Object Therapy', a collaborative human research project and participatory exhibition concerning the public perception of broken objects and their transformative repair, which we define as repair that changes an object's appearance, function or perception. The process by which owners of broken objects were interviewed and their possessions collected for distribution to Australian and international, emerging and established artists, designers and other specialists, for response, is described. This methodology is framed as an approach of critical design that connects a community with another, mediated and traced by the researchers, for the purposes of 'constructing publics', a concept developed from John Dewey by Carl DiSalvo and new materialism theorist Jane Bennett. The critical design aspect in this regard corresponds to making public the problems and perception of broken objects – problems of ownership, obsolescence, and lack of options for conventional repair – within a public exhibition presenting alternative, experimental approaches to repair and reuse. The paper argues that the process of commissioning transformative repair processes thereby constructs a public and, via a new materialist approach, reframes human/non-human relations in ways that acknowledge the agency of materiality in social ecologies.

Preserving objects, preserving memories: Repair professionals and object owners on the relation between memories and traces on personal possessions

Zijlema, A.\(^{a,b}\), Van den Hoven, E.\(^{c,d}\) and Eggen, B.\(^{b,a}\)
\(^{a}\) University of Technology Sydney, Ultimo, Australia
\(^{b}\) Eindhoven University of Technology, Eindhoven, the Netherlands
\(^{c}\) University of Dundee, Dundee, United Kingdom
\(^{d}\) Australian Research Council's Centre of Excellence in Cognition and its Disorders, Sydney, Australia

Traces of ageing and use on the material of products, and memories associated with products, have been found to contribute to product attachment and can stimulate product longevity. We present findings of a qualitative study that focused on the relation between traces of ageing and use on personal possessions and memories and the effects of repair on objects. With this research, we intended to increase our understanding of the role of traces on personal possessions and memories. We interviewed five professionals at their workplace who worked as a restorer or did repairs of personal possessions, and five owners of a repaired or restored possession. The motivations for bringing an object for repair were not only related to the deteriorating condition of the object but were also triggered by situational events or circumstances, such as passing on ownership or knowing someone who could repair the object. We found five different categories of traces among the possessions of the interviewed object owners: Traces of use, traces of ageing, traces of repair, traces of accidents and alterations. We found that objects gained meaning after the repair. When object owners or repair professionals decided not to repair traces, it was often for aesthetical and reminding reasons, but also because it may be how the owner remembered the object. Traces can cue associations to their use in the past, and also to the (imagined) history of the objects. These findings indicate that repair can enhance the cueing of memories and that preservation of meaningful traces may contribute to attachment.

Do-Fix workshops: understanding users’ product repair experience

Terzioğlu N.\(^{a}\)
\(^{a}\) Royal College of Art, London, UK

The characteristics of the current production and consumption system such as high consumption rates, overuse of natural resources and growing waste have engendered various environmental, social and economic problems. Despite the rise of product-service systems and the importance of user experience in design, most consumer goods are nevertheless still considered as throwaway items. It is crucial to understand our behaviour to overcome these problems and offer promising solutions. This paper presents the results of a research that explores users’ repair experience and the factors affecting their repair process aiming to encourage people to repair products more. Four repair workshops were conducted with 52 participants. Participants brought their damaged products to the workshops and chose a suitable method to repair their products. Consequently, their repair experience was explored and three phases including discovery, idea generation and implementation were identified. Additionally, the motivations and barriers around the product repair were discussed. The findings can be of value for designers and design researchers as they can facilitate future attempts to “design for repair”.

Thursday November 9th
14.30 – 15.45
Consumer complaint deadlines and product durability: the role of law and regulation

Pål Strandbakken

(a) Consumer Research Norway (SIFO), Oslo and Akershus University College

Under Norwegian law, the consumer has a right to complain about a product up to five years after purchase, if the product has an average life expectancy of more than two years. This means that producers' liability in Norway is valid for a longer period than in most of the EU, where the consumers' right to redress expires after two years. SIFO is doing a project for the Norwegian Ministry of Consumer Affairs (BLD), in order to assess if this difference in consumer protection influences product durability in the Norwegian market. Is there a correlation between liability period and product life span, and if so, to what degree? One hypothesis might be that the size of the market is too small (with only 5 million inhabitants) for importers and producers to take national regulation of this sort into account. In order to address these questions, we intend to perform three empirical work packages: (1) A check on how many cases handled by the Norwegian Consumer Council that the complaining consumer could not have raised if the country had had a two-year liability; (2) A survey on consumers' knowledge of their rights; and (3) Informant or stakeholder interviews with a number of importers and producers to figure out if they put extra emphasis on durability in the Norwegian market as a result of the five year liability. We will also build on previous research into product durability, performed at the institute since the late seventies.

Do ecolabels extend product service times? An analysis of the product group specific criteria of the European union and Nordic ecolabels

Suikkanen J. (a) and Nissinen A. (a)

(a) Finnish Environment Institute, Helsinki, Finland

Ecolabels are an established means of guiding consumer choices towards product and service options with better environmental performance. The life cycle approach based award criteria of ISO Type I product-specific ecolabels aim to steer the product into the market in an environmentally less harmful direction. In this paper we present an analysis of Product Group Specific Criteria Documents of two ISO Type I Ecolabelling Schemes: the Nordic Ecolabel and the EU Ecolabel. The examination of the product group specific criteria documents indicates that requirements on durability, upgradability and reparability can well be set, and are already included in ecolabel requirements. While durability is already present the criteria for a variety of different product groups, upgradability and reparability are currently required for fewer products, such as computers and televisions mentioned above. Future revisions of product-specific criteria sets present an opportunity to apply circular economy relevant requirements on upgradability and reparability in a broader suite of product groups. Further research on product life spans of ecolabelled products is needed.

Product policy and material scarcity challenges: The essential role of government in the past and lessons for today.

David Peck (a), Conny Bakker (b), Prabhu Kandachar (b), Timo de Rijk (c)

(a) Delft University of Technology, Faculty of Architecture and Built Environment
(b) Delft University of Technology, Faculty of Industrial Design Engineering
(c) Stedelijk Museum, 's-Hertogenbosch

Materials are important in economies, business, innovation activity and products, and they have quickly become essential to maintain and improve our quality of life. The world faces problems concerning material supply, but these concerns are not translated into product design activity, even though history shows that product design policy can play an important role in finding solutions to materials problems. This paper has a focus on the role of governmental policy in ensuring material availability to the state. The case of British WWII Utility Furniture scheme is one where consumer products were designed and developed as a response to severe material shortages. This action is set in the context of wartime conditions where the products were designed, manufactured, used and often reused over a long lifetime, under very stringent governmental control. The control came from the government ministries but was designed and manufactured by the private sector. The furniture scheme was brought in to allow workers to have a furnished home to live in, eat and rest to allow them to work to help win the war. Drawing on policy lessons from the wartime cases this paper makes a comparison of the WWII British approach with a European 21st century action plan for the circular economy, which raises important questions for policy development.
5.1 Product lifetime optimization
Location: Wim Crouwel room
Chair: Rebecca Earley
Thursday November 9th
16.15 – 17.30

Use phase of wool apparel: A literature review for improving LCA
Laitala K., Klepp I. G. and Henry B.
(a) Consumption Research Norway (SIFO), Oslo and Akershus University College of Applied Sciences, Oslo, Norway
(b) Queensland University of Technology (QUT), Science and Engineering Faculty, Brisbane, Australia

This paper presents results from a literature review on use phase of clothing with focus on wool. The aim of the review is to study if there is empirical grounding for assuming that the use phase is different for clothes made of different fibres, and if this information could be used in modelling the use phase. We will answer this question based on studies on wool, and see if use of woollen garments gives different environmental impact than use of garments made of other fibres.

The results show significant differences in how garments of different materials are maintained and used. Woollen garments are more likely to be either dry-cleaned or washed by hand than other textiles, and if washed in machine, the temperature is commonly about ten degrees lower than average washing temperature in Europe. Woollen garments are less likely to be dried in a clothes drier. Even the washing frequency differs, as woollen products are used about twice as many days between the washes than similar cotton products. The studies indicated that woollen garments had longer than average lifespans.

We conclude that fibre content contributes to the way consumers take care of and use their clothing, and should be taken into consideration in tools developed for comparing the sustainability of garments of various textile materials.

Intelligent disassembly of components from printed circuit boards to enable re-use and more efficient recovery of critical metals
Kopacek B.
(a) Austrian Society for Systems Engineering and Automation, Vienna, Austria

Based on previous experiences in intelligent disassembly of components from printed circuit boards our goal was to develop an economic solution for reducing the amount of material for the later hydrometallurgical recovery process and to recognize reusable parts on printed circuit boards. Usually the hydrometallurgical recovery process is very time consuming and therefore the recovery rate still relatively low. Therefore, it is beneficial to enrich the content of critical metals in the input fraction by extracting only those components from printed circuit boards that are rich in the target metals (e.g. tantalum, rare earth, platinum group metals).

In addition, there are reusable parts on printed circuit boards which have a high enough resell value on the market. These components must be dismantled, but in a more careful way in order not to destroy the function of the component by thermal or mechanical influences.

One advanced possibility for solving both problems is the adaptation of our semi-automated, flexible disassembly cell for printed circuit boards. This modular cell was developed some years ago for removing re-useable electronic components from old as well as new printed circuit boards. Main modules are a transportation system, a vision system and heating-unsoldering stations.

In this contribution, this new approach will be described from the technological as well as from the economic point of view.

Strategies for food longevity
van Genuchten, E.J.S., Mulder, I.J. and Schaaf, N.
(a) Delft University of Technology, Delft, Netherlands
(b) ConComCow, Rotterdam, Netherlands

Although food has been circular by nature, the current food supply chain has turned into an unfortunate linear system. The challenges of transitioning towards a sustainable food eco-system requires radical changes and new perspectives, where things are done differently. Starting with related work in the field of design for product longevity, the current work explores the role of design in developing food systems on eco-systemic level that work as efficient as possible, and create a world without waste. Eight local initiatives in Rotterdam have been studied. From the lessons learned, nine strategies were formulated. Although these strategies seem to work well and are promising starting points for innovation, it remains difficult to build sustainable business models around these strategies that can be scaled and sustained. Initiatives oftentimes keep struggling with the current system and finding the proper scale for their business. It can be concluded that design promises to play an important role in accelerating this transition towards a circular and future-proof food system.
5.2 Circular economy and policy

**Planned obsolescence: the government’s choice?**

Ober E.\(^{(a)}\), Dell’Anno B.\(^{(b)}\), Drèze J.R.\(^{(c)}\), Herrmann L.\(^{(a)}\), Luciano A.\(^{(d)}\), Maltry R.\(^{(e)}\), Oehme I.\(^{(f)}\), Schmon B.\(^{(a)}\) and Ventère J.P.\(^{(g)}\)

\(^{(a)}\) Federal Ministry of Agriculture, Forestry, Environment and Water Management, Vienna, Austria  
\(^{(b)}\) Ministry for the Environment, Land and Sea, Rome, Italy  
\(^{(c)}\) Federal Public Service for Health, Food chain safety & Environment, Brussels, Belgium  
\(^{(d)}\) Italian National Agency for new technologies and sustainable economic development, Rome, Italy  
\(^{(e)}\) Federal Ministry for Environment, Nature Conservation, Building and Nuclear Safety, Berlin, Germany  
\(^{(f)}\) Federal Environment Agency, Dessau-Rosslau, Germany  
\(^{(g)}\) Ministry for the Ecological and Inclusive Transition, Paris, France

Representatives of five Environmental Ministries and attached Agencies examined political instruments to ban products with built-in defects designed to end the product’s life-cycle. The focus primarily laid on better consumer information. A lack of information concerning the durability and repairability of products creates an asymmetry in the market balance between producers and consumers. The need for common actions on EU-level was highlighted. Among these political instruments are voluntary measures and innovative economic models. The European legal framework for consumer protection has to be further evaluated, more specifically the concept of warranty law. With political feasibility being considered, conclusions were drawn unanimously. However, the authors take into consideration the findings of different national studies that could not validate the accusation of planned obsolescence.

**Product lifetimes through the various legal approaches within the EU context: recent initiatives against planned obsolescence**

Michel A.\(^{(a)}\)

\(^{(a)}\) KU Leuven, Campus Brussels, Belgium

Our today’s society is often called a ‘throwaway society’, based on a linear ‘take-make-use-dispose’ economy. Many studies point out that median lifespans of certain consumer products are in decline. One of the main sources of this problem is the phenomenon of ‘planned obsolescence’, covering all types of techniques used to artificially limit the durability of a manufactured good in order to stimulate repetitive consumption. Various types of planned obsolescence are omnipresent in our daily life. Planned obsolescence has huge drawbacks, for consumers as well for the environment, and, arguably, its potential positive side effects do not outweigh these drawbacks. The willingness to shift towards more durable and sustainable products has led to major legal developments and proposals over the past years. The purpose of this paper is to outline some of the various approaches followed in Europe to tackle planned obsolescence. After providing a glimpse into the EU policy actions, the paper will describe the recent purely national initiatives undertaken in France, Belgium and Germany.

**Implementing “preparation for re-use” in WEEE management: An analysis of the European experience & recommendations for Ireland.**

McMahon K.\(^{(a)}\), Fitzpatrick C.\(^{(a)}\) and Johnson M.\(^{(a)}\)

\(^{(a)}\) Dept. of Electronic & Computer Engineering, University of Limerick, Limerick, Ireland

Proper treatment of waste plays an important role in global concerns regarding resource efficiency and climate change. Waste electrical and electronic equipment (WEEE) is of particular importance due to high use of critical resources and production/recycling energy as well as the potential for toxic pollution when improperly disposed of. Preparation for re-use plays an important role in alleviating these issues.

Within Ireland the regulated preparation for re-use sector exists in an embryonic stage. This paper identifies supports, through analysis of EU systems, to encourage the growth of the Irish system in the form of recommendations for policy makers, providing a baseline for other systems to do the same.

EU member states reporting the highest re-use rates of LHA and IT equipment were identified through Eurostat data; analysis of the barriers/facilitators to this success within each country was conducted through interviews with reportedly successful organizations. Subsequently, Irish stakeholders were interviewed in order to record input on the current system, contrast it with successful models and identify what action might be needed to move forward.

Several themes were identified through these analyses as related to success in preparation for re-use activities including involvement of social enterprises, access to equipment, segregation of waste with potential for re-use at the earliest point possible, adherence to quality national/international standards, a positive relationship with the Producer Representative Organizations responsible for enabling access to the materials, and implementation of targets when necessary.

Recommendations are presented in regards to policy supporting preparation for re-use in the Irish system.
5.3 Consumer and cultural perspectives

Location: Joost van der Grinten hall
Chair: Ben Bridgens

Thursday November 9th
16.15 – 17.30

Taking good care: investigating consumer attitudes to product maintenance.

Young G.\(a\)

\(a\) Sheffield Hallam University, Sheffield, UK

Building on the work undertaken in the ‘Caring Project’ (Gwilt, Leaver, Fisher, Young, 2015), this secondary inquiry seeks to ascertain specific aspects of maintenance practices that are employed by users and to understand the drivers behind some of the key decisions taken when maintaining products. Through an empirical study that involved gathering data using methods including a survey, observations and cultural probes, the findings reveal some of the motivations behind the choices of those who self-maintain and those who choose to have that work carried out by a service provider. Moreover some insight into the prompts that trigger why users instigate product maintenance, and the equipment selected and used in the maintenance of common objects are also discussed. These initial insights support the potential for a larger study with the ultimate aim of influencing designers and manufacturers in the development of longer lasting products.

Carative factors to guide design development process for object-owner detachment in enabling an object’s longevity

Choi Y.\(a\), Stevens J.\(a\), and Brass C.\(a\)

\(a\) Innovation Design Engineering, Royal College of Art, London, United Kingdom

During the 20th century the cultural and economic value of products dramatically changed as the availability and affordability of mass-produced, low cost goods increased in the marketplace (Walker, 2006). We buy things that end up never used, we store objects that are never needed, find the extra storage space for the object that doesn’t fit in our house. Most of the things we own just sit there gathering dust, eventually to be thrown away although they are still perfectly functional. The exploration of ways to let go of objects has important implications beyond the conventional interpretation of object-user detachment. To care for one’s possessions is as much about maintaining and repairing objects to keep as it is about letting objects go to a good home. In this sense, carative factors are a useful way to address ways of object-user detachment and help to promote re-use and repair to sustain and extend product lifespan.

This paper explores how the carative factors can be used to inspire and stimulate designers to explore ideas, and enable new ways to approach problems of attachment and consumption, and drive creative solutions that encourage letting go. A set of characteristic factors are presented in card format, serving as a stimulus toolkit and tested through a workshop and live design projects. The findings, potential benefits of the toolkit and effects on products lifespan will be further discussed.

Consumers’ attitudes towards product care: an exploratory study of motivators, ability factors and triggers

Ackermann L.\(a\)(b), Mugge R.\(b\) and Schoormans J.\(b\)

\(a\) DE|RE|SA, Salzburg University of Applied Sciences, Puch/Salzburg, Austria
\(b\) Department of Product Innovation Management, Delft University of Technology, Delft, The Netherlands

To contribute to a more sustainable way of consumption, products should stay usable as long as possible. Therefore, it is necessary to take care of products. Product care should be understood as any action that helps prolonging the lifetime of a product, such as maintenance, repair etc. These product care activities can be conducted by the consumer or by a service. Our interview study helps to understand consumers’ current product care behaviour towards products of different categories. Our study is based on Fogg’s behaviour model, which states that motivation, ability and triggers have to be present at the same time to lead to certain behaviour. We were able to identify different motivators (e.g. pleasure, price, functionality), ability factors (e.g. tools, time and effort) and triggers (e.g. appearance triggers, social triggers) for product care. Based upon the findings of this study, strategies that enhance product care are suggested and relevant aspects for future research are proposed.
5.4 Business opportunities

Location: Studio 13
Chair: Erik Jan Hultink

Thursday November 9th
16.15 – 17.30

Sustainable product management by integrating physical and digital lifecycles

Baumgartner R. (a)

(a) University of Graz

The concept of circular economy has received an increased interest of public, societal and corporate actors in the last years. To realize a circular economy, products have to be designed and managed in a way that material flows are closed and energy use is minimized along the physical lifecycle of a product, thus a lifecycle-wide sustainable product management is needed. The digital revolution can be an immense enabler for a transition towards a circular economy and for sustainable product management. The physical lifecycle is represented in data systems of companies and institutions involved in a value chain. Products themselves collect and report more and more data during their usage. But until now, all these data sources are disconnected and not used for a sustainable product management. If it is possible to map the digital product lifecycle by connecting different data sources, a digital twin of the physical product lifecycle can be created. This digital lifecycle enables a dynamic management of the physical lifecycle by using actual, up to date and correct data for sustainable product management. The goal of this contribution is to describe sustainable product management as a combination of the physical and the digital product lifecycle, the research is based on a literature analysis and conceptual modelling.

Smart-circular systems: a service business model perspective

Alcayaga A. (a) and Hansen E. G. (a)

(a) Institute for Integrated Quality Design (IQD), Johannes Kepler University Linz (JKU), Linz, Austria.

The Internet of Things and the amplified capabilities of smart products can be increasingly utilised for the development of feedback-rich systems and loops throughout the entire product life cycle. By adopting the IoT and collecting data during product utilisation, companies can replace the end-of-life concept with product life extension and circular loops. In this sense, service business models hold the greatest potential to optimise the utilisation of goods over time. These models allow a reduction of the overall life cycle costs and contribute to resource-efficiency and the transition towards a circular economy. This paper introduces the concept of smart-circular systems that reflects the interplay between the Internet of Things, the circular economy and service business models and presents a conceptual framework for further empirical analysis of this phenomenon. The framework focuses on product-service systems and more broadly on services business models that optimise the utilisation of goods over time through the amplification of circular activities by the introduction of smart enablers. It also considers three main business models types and tactics for successful implementation of service business models.

Additive manufacturing for circular product design: a literature review from a design perspective.

Sauerwein, M. (a), Bakker, C.A. (a) and Balkenende, A.R. (a)

(a) Faculty of Industrial Design Engineering, Delft University of Technology, Delft, the Netherlands

Circular product design is a relatively new approach to design suitable strategies to realize circular products. Additive manufacturing (AM) is seen as a promising enabling production process. It has digital and additive characteristics, which makes AM different from conventional production techniques. However, it is yet unclear how this technique can contribute to circular product design in practice. In this paper, a literature review is placed in context, i.e. the results of a literature review on sustainability opportunities in AM are compared to five typical design cases in a design review.

The outcomes of the literature study reveal the aspects of the digital and additive characteristics of AM, that lead to potential sustainability opportunities. We compared these aspects to the circular design strategies as described by Bakker et al. (2014) and Bocken et al. (2016) in the context of the five selected design projects. Each project is described in terms of circular design strategies and how these were achieved through additive manufacturing.

Using design practice to reflect on the outcomes of the literature review resulted in a better understanding of the potential of additive manufacturing for circular product design. The relation between the sustainability aspects of AM and the circular design strategies were made explicit. AM seems to be especially suitable to customize parts to fit existing products and to contribute to new opportunities regarding material recycling. These findings deserve further exploration in order to understand the motives for implementation in circular product design.
6.1 Design for product longevity

Location: Wim Crouwel room
Chair: Ruth Mugge
Friday November 10th
09.00 – 10.15

The Circular Pathfinder: development and evaluation of a practice-based tool for selecting circular design strategies

Van Dam, S.S.\(^{(a)}\), Bakker, C.A.\(^{(a)}\), De Pauw, I.C.\(^{(b)}\), Van der Grinten, B.\(^{(b)}\)

\(a)\) Delft University of Technology, Delft, Netherlands
\(b)\) IDEAL&Co, Amsterdam, the Netherlands

The Circular Pathfinder tool, which provides guidance to companies looking for appropriate circular design strategies, was developed based on OEM (original equipment manufacturer) case studies. Ease of use was one of the main requirements during development of the tool, resulting in a software-based guide that asks a maximum of ten product-related questions, after which it gives a recommendation for one or more specific circular design strategies. The advantage of a practice-based tool is that the practical relevance is, in all likelihood, high. The disadvantage, however, is the lack of scientific validation. This paper presents a literature review of the decision variables and heuristics of the Circular Pathfinder, with the aim to uncover any discrepancies between practice and literature. The main finding is that the focus on practical usefulness of the tool has led to excessive reduction of the complexity inherent in strategic circular design decisions. Recommendations for improving the Circular Pathfinder tool are given.

New product development and testing strategies for clothing longevity: an overview of a UK research study

Cooper T. H.\(^{(a)}\), Oxborrow, L.\(^{(a)}\), Claxton, S.\(^{(a)}\), Goworek, H.\(^{(b)}\), Hill, H.\(^{(a)}\), McLaren, A.\(^{(a)}\)

\(a)\) Nottingham Trent University, UK
\(b)\) University of Leicester, UK

Many garments have short life-spans, contributing to excessive carbon emissions, water consumption and waste. This paper reports on a research project which aimed to identify expectations of clothing longevity, examine the NPD process within the supply chain and identify opportunities for change, evaluate the potential for innovative technologies and improved product testing, and explore business practices aimed at more sustainable approaches to NPD. The paper provides an overview of the two year project, presenting key findings from data collection that included interviews with 31 industry practitioners, three consumer focus groups, three industry and consumer round tables, an expert workshop, and four pilot actions undertaken with UK clothing retailers to evaluate key issues. The research identified and explored themes relating to NPD that could enable increased garment lifetimes, which were consolidated into six areas: the adoption of advanced textile processes and finishing techniques, action to overcome constraints on appropriate product testing, the potential for retailers to influence consumer behaviour, a loss of technical expertise and lack of multi-disciplinary collaboration, failure to embed good practice early in the NPD process, and evidence to encourage retailers and brands to adopt new business models. Industry and government policy recommendations were proposed to improve knowledge-sharing, strengthen the business case and influence consumer behaviour, while further research may be needed on the adoption of new garment and textile technologies, the business case and the global context of the clothing industry

Developing scenarios for product longevity and sufficiency

Dewberry E.L.\(^{(a)}\), Sheldrick L.\(^{(b)}\), Sinclair M.\(^{(a)}\), Moreno M.\(^{(d)}\) and Makatsoris C.\(^{(d)}\)

\(a)\) The Open University, Milton Keynes, UK
\(b)\) Imperial College London, UK
\(c)\) Loughborough University, Loughborough, UK
\(d)\) Cranfield University, Cranfield, UK

This paper explores the narrative of peoples’ relationships with products as a window on understanding the types of innovation that may inform a culture of sufficiency. The work forms part of the ‘Business as Unusual: Designing Products with Consumers in the Loop’ [BaU] project, funded as part of the UK EPSRC-ESRC RECODE network (RECODE, 2016) that aims to explore the potential of re-distributed manufacturing (RdM) in a context of sustainability. This element of the project employed interviews, mapping and workshops as methods to investigate the relationship between people and products across the product lifecycle. A focus on product longevity and specifically the people-product interactions is captured in conversations around product maintenance and repair. In exploring ideas of ‘broken’ we found different characteristics of, and motivations for, repair. Mapping these and other product-people interactions across the product lifecycle indicated where current activity is, who owns such activity (i.e. organisation or individual) and where gaps in interactions occur. These issues were explored further in a workshop which grouped participants to look at products from the perspective of one of four scenarios; each scenario represented either short or long product lifespans and different types of people engagement in the design process. The findings help give shape to new scenarios for designing sufficiency-based social models of material flows.
Management of material cyclicity potential: example of electrical and electronic products
Shevchenko T.(a) and Kronenberg J.(b)

This study is aimed at justification of the theoretical foundations of management of material cyclicity potential (MCP), including materials used in electrical and electronic products (EEP). In our opinion, the "cyclicity" of material should be studied from the perspective of the potential of materials to be multiply used. Such an approach allows to identify all possible forms of MCP manifestation in space and time. We suppose that the process of increasing of MCT starts with the design of the cycle of material multiple turnover (MMT) by forming an optimal range of products within which certain material sequentially turns, and continuous with the forming of MCT within adjacent product life cycles (located next in the specified range). The priority in the turnover sequence should be given to those products that are characterized by minimum change in the material quality parameters at the output of the turn. So the focus on "cycle of MMT" rather than "product life cycle" is important for ensuring the maximum number of turns of material because it highlights that one deals with a range of products in which the same material is sequentially used, throughout their lifecycles, rather than only with one product. The suggested approach to closing material cycles is based on the concept of MCP, and unlike existing approaches, it provides the moving of certain material along a specified path – an optimal range of products thereby forming a cycle of MMT with maximum number of turns. This path obviously can be adjusted with each subsequent turn of material because a new products and technologies are being continuously designed. In the context of the circular economy, the proposed theoretically-methodical design of sustainable use of materials is intended for the rational allocation of new and circulating materials in an economic system.

The circular economy fashion communication canvas
Han, S.L-C.(a), Henninger, C.E.(b), Blanco-Velo, J.(a), Apeagyei, P.(a) and Tyler, D.J.(a)

Current design thinking focuses on incremental improvements to a linear system in which products are designed, produced and eventually disposed of. This continued consumption has resulted in over 1 million tonnes of discarded clothing and textiles entering into landfill each year in the UK alone. The effect of this high volume of waste is not only the loss of embodied energy and value, as re-useable items are disposed of, but continued environmental degradation through greenhouse gas emissions, toxic pollution and rapidly declining landfill space. As much as 70% of textile waste in the UK is sent to landfill or incineration from municipal waste collections. Whilst consumers are increasingly aware of the consequences of continued consumption, there is limited understanding of how to act more responsibly. Online sources of communication mean that although more information is available than ever before, confusion over terminology and the authenticity of messages can lead to in-action on the part of all stakeholders. In order to investigate these problems key points at each stage in the fashion and textiles cycle were analysed using an exploratory sequential mixed methods approach combining case studies, semi-structured interviews and a consumer survey. Brands and designers working to create change by offering more conscientious product choices are struggling to connect with mainstream fashion consumers, hindered by a lack of industry acceptance and media coverage. Barriers to scaling up circular economy fashion strategies include a lack of market knowledge relating to consumers and the most effective promotional and retail strategies. These findings present significant evidence to guide the development of an effective fashion communication strategy for a circular economy. Academic implications of the research include the identification of additional insights needed to establish more effective methods to communicate the economic, social and environmental benefits of textile reuse, recycling and upcycling to consumers and the fashion industry, leading to further research and contributions to knowledge. Practical implications include key contributions to the development of an operational framework to integrate circular economy fashion strategies into mainstream production and retailing. Originality lies in determining the existing practices already employed in this sector of the fashion industry and examining their effectiveness against the mainstream, in order to more effectively communicate to the benefits of sustainable, circular consumption in an industry which has so far thrived on linear consumption, novelty and obsolescence. In this way, marketing strategies can be developed for circular economy fashion which emphasise longevity, product lifetime optimisation, new forms of consumption and user experiences in a circular economy. The circular economy communication canvas serves a purpose to facilitate positive decision making for all stakeholders.

Branding matters more than reparation for extending smartphone lifespans: evidence from used smartphone sales on eBay
Makov, T.(a)

Despite the important role intangibles such as brand play in shaping consumption, the environmental consequences of intangibles have been rarely explored. Analyzing 500,000 listings of used Apple and Samsung smartphones sold in 2015 and 2016 via eBay, we use depreciation as a proxy for useful lifespan to examine which product properties make smartphones last longer. Our results suggest that although reparation and large memory size, are typically though of as life extending, in practice they have limited impact on smartphones’ useful lifespan length. In contrast, we show that brand, an intangible property, has a meaningful impact on useful lifespan and the efficient use of materials and energy, that in this case, take the form of 12.5 months of additional use per smartphone. These findings suggest that product lifespans are not homogenous but vary as a function of different product properties. Moreover, we show that intangible properties (e.g. brand) can be of greater importance for promoting sustainable consumption and resource efficiency than functional properties which are often advocated for.
Personalisation from a design practice perspective

Bernabei R.\textsuperscript{(a)}, Power, J.\textsuperscript{(b)}
\textit{a) University of New South Wales, Sydney, Australia}  
\textit{b) University of Tasmania, Launceston, Australia}

The Internet is facilitating new ways of designing, manufacturing and distributing products. This has led to a more democratic, open-design approach and has resulted in users having more involvement in the design process than ever before. In particular, designers are shifting away from designing a finished product, to either designing components, a template or a set of tools which the user interacts with to finalise and/or personalise the product. This way of approaching design is still in its infancy. The authors’ have termed this design framework, as it applies within product design, ‘user-completion’. The authors’ propose that the user-completion framework operates at the intersection between mass-customisation and craft. The skills and knowledge sets associated with mass-customisation and craft, presents challenges and opportunities for both the designer and user. The user-completion framework enables users to personalise the end product and therefore requires designers to shift their conceptual approach, by handing-over more design control to the users. It is hoped that by doing so, and by engaging the user in the product’s completion, a stronger emotional bond will be generated between the user and the final product. This design process also anticipates an added value and a longer life cycle for the product.  
The ‘user-completion’ framework proposed by the authors will be outlined, and supported with the three case study examples of work. Through these case studies the value of users being involved in the design process is explored, as is their engagement with craft and their perceived emotional value of the resulting products.

Satisfaction matters: design that learns from users’ sensory and emotional responses to clothing

Burcikova, M.\textsuperscript{(a)}
\textit{a) Centre for Fashion and Costume Thinking, University of Huddersfield, UK}

Researchers across disciplines increasingly acknowledge that embracing the multi-sensory character of everyday perception can provide invaluable insights for social and design interventions that aim to improve the experience of products and services. Where fashion design traditionally focuses on the aesthetic, visual side of design, empirical studies prove that the way clothes feel, sound, or smell, is equally important for the way they are experienced and appreciated in everyday use. The aim of this paper is therefore to explore how users’ sensory engagement with clothing can inform the creative practice of designers who wish to design for continuity and increased user satisfaction. Satisfaction with a garment often leads to its repeated use and accumulation of pleasurable memories that can both positively influence the active lifetime of the garment. The paper draws on my on-going PhD research and presents initial findings of the second phase of my project (in-progress), which consists of a series of wardrobe studies conducted in participant’s homes. The results so far indicate that sensory experiences connected with clothing, although rarely explicitly acknowledged by users, can significantly affect user satisfaction and therefore deserve a greater attention in the context of sustainable design and design for longevity.
6.4 Design for product longevity
Location Studio 23/24
Chair: Jan Schoormans

Redefining retail experiences: formulating ideas for the future of retail design to promote product longevity
Matheny R.\(^{(a)}\)
\(a\) The Ohio State University, Columbus, Ohio, USA

This paper presents a series of case studies examining selected slow fashion retailers’ use of storytelling elements within their respective store environments to communicate their brand’s sustainable process and mission. The term slow fashion, coined by Kate Fletcher, informs and encourages conscious consumers on responsible product sourcing and manufacturing, allowing them to feel connected to their local and global community. For slow fashion brands, fostering a strong and nurturing relationship between consumer and producer is invaluable, however few of these retailers capture that goal within their retail experience. Striving to educate and entice consumers towards more sustainable consumption, this paper presents case studies examining how storytelling elements are utilized within the retail environment to forge the consumer-producer connection. Currently, many slow fashion retail environments lack storytelling elements, varying little from fast fashion stores. When the retail story and experience is not differentiated from those promoting mass consumption, products hold little emotional value and are disposable. This paper describes how three North American slow fashion brands (Shinola Detroit, Levi’s, and The Local by Lululemon) implemented storytelling within their store, educating consumers towards shifting their behaviors. Understanding the emotional connection between storytelling components and products reinforces slow fashion’s goal by elevating products from disposable to cherished artifact. Through this analysis, designers and retailers will be provided with tools to better educate their consumers and promote a slower consumption lifestyle.

The role of product designers in the transition towards the circular economy: a reality check
Sumter D.X.\(^{(a)}\), Bakker C.A.\(^{(a)}\) and Balkenende A.R.\(^{(a)}\)
\(a\) Industrial Design Engineering, Delft University of Technology, Delft, The Netherlands

This paper examines the role of product designers in the transition towards the circular economy. Both scientific and grey literature show remarkable optimism when it comes to role strategic and coordinating role designers could play in this transition process. However, there has been little examination of the actual role and influence designers have in practice. In this paper we review the roles that designers play in the transition towards a circular economy according to literature. Through semi-structured interviews, we uncover the views of designers themselves, which we then use to make a comparison. Our main conclusion is that designers experience a lack of knowledge and/or work in predetermined solution spaces, which prevents them from taking on the role that is expected in literature.
7.1 Design for product longevity
Location: Wim Crouwel room
Chair: Casper Boks

Reducing clothing production volumes by design: a critical review of sustainable fashion strategies
Maldini, I.(a) and Balkenende, A.R.(b)
a) Amsterdam University of Applied Sciences and VU University Amsterdam, Amsterdam, Netherlands
b) Industrial Design Engineering, Delft University of Technology, Delft, Netherlands

Based on a literature review, this article discusses how the challenge of diminishing clothing production volumes has been approached within the field of sustainable fashion. We identify six common strategies in literature and discuss the approach of user involvement in the process of design and/or manufacture of garments in detail. A critical analysis of the state of the art in the field points out that these strategies have been constructed, studied and promoted without empirical validation. The article concludes with a recommendation to move forward from conceptual to empirical studies. Analyses of existing initiatives and their results in terms of consumer buying behavior and obsolete inventory are recommended as first steps towards validation.

Taxonomy of design strategies for a circular design tool
Moreno M.A., Ponte O., Charnley F.
Centre for Design, Cranfield University, Bedfordshire, UK

This paper presents the development of a circular design tool created from a taxonomy of design strategies related to circular economy aspects that emerged from an extensive literature review. The taxonomy was presented to 10 experts on circular economy and design through a survey to identify an importance factor that could guide product designers to rate different concepts. The taxonomy and their rates are presented in a circular design tool to help product designers to avoid uncertainty of which design concepts meets circular economy aspects. A pair of trainers are used as an example on how the circular design tool can be used. The paper discusses how the chosen design meets the identified circular design aspects and acknowledges that more trials with different product categories are needed to determine further areas of improvement. A larger survey is also suggested to develop a more accurate scoring system when it comes to rate each concept. The paper concludes that more detail guidelines are needed for product designers in their early career, so they can consider design for circular economy. In addition, the final remarks elucidate that future research is needed to cross-reference the circular design aspects with technical aspects of each product, new manufacturing technologies and materials.

Decontaminating experiences with circular offerings
Baxter W.(a), Aurisicchio M.(a), Mugge R.(b) and Childs P.(a)
a) Imperial College London, London, UK
b) Delft University of Technology, Delft, The Netherlands

Keeping a product offering in the system through continued use and between multiple users creates the potential for interactions which become contaminated. These contaminated interactions can cause a barrier to material circulation and extended product lifetimes. This study seeks to identify the underlying design strategies useful in addressing contaminated interaction. Strategies were identified through an exploration of possible solutions to negative contamination in two phases. Phase I involved identifying 70 existing solutions to instances of negative contaminated interaction and abstracting these to identify a more fundamental underlying principle. In Phase II, designers participated in a brainstorming session to identify as many solutions as possible to several contaminated interaction design briefs. The resulting 155 solutions were analysed together with the other data to generate a final set of strategies. In the end, eight strategies distilled from the analysis which are used to address contaminated interaction. The strategies represent preventative and responsive solutions applicable to various elements of the contamination process.
Planned obsolescence: who are those planners?

Longmuss J.\textsuperscript{(a)} and Poppe E.\textsuperscript{(a)}
\textsuperscript{a) SUSTAINUM - Institute for Sustainable Economy, Berlin, Germany}

There is a controversial discussion on the phenomenon of “planned obsolescence”. However, shrinking product lifetimes and product quality do not prove that actors in the product development process take conscious decisions toward premature obsolescence. Current product faults like exploding batteries in Samsung’s Galaxy Note 7 foster the suspicion that manufacturers are also struggling with unintended product obsolescence. The relevant question is in which limits the planning of product lifetimes leads to intended and unintended consequences. The reasons and intentions behind product features and whether these features are intentionally at all can just be determined in direct contact with the actors of the product development processes. The research project LOiPE could establish contacts in strict confidence to development departments of 23 major German companies. The objectives of the survey were to find out about the development process in their point of view, its paradigms and their experience with “planned obsolescence”. All interviewees assured that when they had to balance cost against lifespan, lifespan always prevailed. The allegation of a deliberately intended premature obsolescence was vehemently rejected by all of them. The limitations through obsolescence are caused by the basis conditions of developing and producing: rising complexity, increasing speed of innovation cycles and high cost pressure. These conditions and their constraints leave little space to single actors of the development process and to companies. In this sense obsolescence is systemic. So, a perspective towards more sustainable production and consumption lies in a combination of different approaches.

Developing a quantitative research method on planned obsolescence in architecture

Akyurek K. B.\textsuperscript{(a)} and Ciravoğlu A.\textsuperscript{(b)}
\textsuperscript{a) Yildiz Technical University, Faculty of Architecture, Department of Architecture, Istanbul, Turkey}

Planned obsolescence, a developed theory to maintain the continuity of production by consuming, manifests itself in a large number of products since its first emergence. Through the use of substandard materials, the short-lived products ensure rapidity and continuity in consumption. Additionally, the newer and different options awaken desire of consumers to change their 'obsolete' products. Thus, planned obsolescence becomes both a trigger and a consequence of the consumer society. In contrast to broad discussions on the scheduled lifespan of the products in economics and industrial design, a very small number of studies focus on the building lifetimes. Indeed, planned obsolescence is also a problem of architecture but surely has been carried within a different process and approach than with industrial products. The initial aim of this study is to point out the existence of planned obsolescence in architecture by exposing the ambiguity behind the determination of building demolitions (in other words consciously defined 'expiration dates'). In the framework of the paper, an ongoing urban transformation project in Istanbul: Tarlabası Renewal project is examined as a case study. By doing so, the crucial variables that have effects on economic existences of the buildings are underlined in the specific case. Due to the constitution of a basic equation, this study tries to demonstrate the possibility of a developing quantitative research method on building lifetimes in replace of stereotypical assumptions. Consequently, it is envisioned that the subjectivity concerning the demolitions of buildings shall be controlled with the determination of prominent factors and their ratios in overall.

Planned obsolescence in the circular economy

Zeeuw van der Laan A. and Aurisicchio M.
\textsuperscript{Dyson School of Design Engineering, Imperial College London, London, United Kingdom}

Objective: Ordinary Fast-Moving Consumer Goods (FMCGs) often thrive on implementing the planned obsolescence business strategy, i.e. controlling product lifetime through material selection. This wasteful and resource-depleting linear approach to production has resulted in goods that offer convenience along the lifetime of the consumable components, and are re-purchased after disposal. Contemporary FMCGs have similar characteristics but different product-service systems (PSSs). The circular economy (CE) proposes PSSs as an opportunity to increase the circularity of resources. This paper investigates these PSSs implemented in contemporary FMCGs and reviews opportunities for the planned obsolescence strategy in the CE. Method: Customer Journey Maps (CJMs) were developed for three contemporary FMCGs (Fuji disposable camera, HP ink cartridge, Kartent) and compared to the map for a standardised ordinary FMCG. Result: In contemporary FMCGs the inventory and maintenance phases are eliminated by introducing services operating in the purchase, use and disposal phases. Services in the disposal phase are critical to enable the circularity of contemporary FMCGs. Conclusions: Consumers do not need inventory if the services in the purchase and use phases are aligned and available at the right time and place. This increases convenience, but does not make the use of the products more compatible with a CE. The real opportunity for FMCGs is in the elimination of the maintenance phase and the integration of end-of-life services. If planned obsolescence is communicated clearly to customers through lifetime indicators that allow involvement in end-of-life services, it could shift FMCGs towards a circular performance-based approach to production.
7.3 Consumer and cultural perspectives
Location: Joost van der Grinten Hall
Chair: Deepali Sinha-Khetriwal
Friday November 10th
11.00 – 12.15

Design for the wise consumer
Luchs, M.
College of William & Mary, Williamsburg, Virginia, United States

In response to dominant patterns of mainstream consumption evident in developed economies, Consumer Wisdom offers a positive alternative whose objective is to simultaneously promote the well-being of the individual, society, and the natural environment. The current research has two objectives. First, through a series of in-depth interviews with individuals nominated for their wisdom, we provide an empirically grounded theory of Consumer Wisdom. Our theory of Consumer Wisdom is composed of five interdependent facets: Contemplation, Intentionality, Emotional Mastery, Openness, and Transcendence. Next, we synthesize design principles from existing design frameworks and philosophies that align with the facets of consumer wisdom, and we build on these to reflect new insights derived from our theory.

Deconstructing cultural values of products: implications for sustainable design
Dhadphale T.
Iowa State University, Ames, United States

In a global era where products are reaching across international boundaries, designers are increasingly challenged to design for diverse cultural context. Designers are agents of cultural change and should be cognizant of the impact their products have on local markets. The key for developing culturally appropriate products lies in understanding how cultural objects acquire and communicate cultural meanings. The goal of this paper is to deconstruct and categorize cultural meanings associated with objects and highlight the key determinants that contribute to cultural values. Cultural product images and phrases were analysed using a four-layered model for classifying cultural meanings. Participants were then engaged in a laddering interview to understand the key determinants of cultural values. The analysis reveals eight key determinants of cultural values. The determinants are mapped across four key continuums: appearance–representation, self-identity–group affiliation, personalization–shared belongingness, and stories–memories. In addition, the determinants of cultural values are compared with the key determinants of product attachment. Findings of the study reveal a strong overlap between the determinants of cultural values and product attachment. The paper also outlines a framework for achieving culturally sustainable design. The outcomes of this study have several implications for designers and educators that aim to achieve culturally sustainable design. This study believes that products that reflect cultural values have a higher emotional attachment to consumers resulting in longer life-spans and culturally sustainable consumption.

The look of rough: visual and tactile perceptions of cosmetically aged materials
Manley A.H.G.(a), Lilley D.(b), Hurn K.(b) and Lofthouse V.(b)
a) Southampton Solent University, Southampton, UK
b) Loughborough University, Loughborough, UK

The aesthetics of material performance within design is typically only considered up to the point of sale, a false end state in which the ‘newness’ of the product is protected by the hermetic packaging in which it is sold. Beyond this, the ‘ageing’ of a material is thought of only in terms of utility or easily measured technical parameters such as durability or toughness, and rarely reflects upon, or accounts for, the user’s experiential relationship with the material. Here, we explore changes in tactile and visual perceptions when sample materials have been artificially aged through the application of a taxonomy of damage observed from real world products. This paper argues that to expand our current knowledge in material culture and to assist in providing a more nuanced understanding of the user’s long-term relationship with materials, we, as designers, need to observe, record and reflect upon attitudinal reactions to aged and used materials.
Over the hill? Exploring the other side of the Rogers innovation diffusion model from a consumer and business model perspective

Wells P. and Nieuwenhuis P.
Cardiff Business School, Cardiff University, Cardiff, Wales, UK

The Rogers model of innovation diffusion has long featured in accounts of the penetration of new product technologies into society (Rogers, 2003). The contention in this paper is that this model is in fact only half complete, for it deals exclusively with the uptake of new technologies rather than their retention or abandonment. Taking the Rogers model as a point of departure, this paper seeks to characterize consumers who retain technologies, then identify business models designed for those consumers. Implicit in the Rogers model is that existing technologies become obsolete, and hence displaced by the emergent technologies. In reality, a new technology may be additional to the suite of products available to consumers, and therefore not necessarily associated with the direct displacement of an existing technology. However, much product innovation is concerned with generational improvements in technologies or with new technologies that, while having no direct equivalent in current use, do indeed displace existing solutions. The paper therefore analyses the contribution of extended product lifetimes within circular economies. The relevance of this contribution is that product longevity is one means by which lifestyles characterised by material affluence are reconciled with resource scarcity. Product longevity has the potential to contribute to slowing down the ‘velocity’ of material flows within the circular economy, and hence defer the investment of further energy (and materials) into the next cycle of consumption. Bock et al. (2012) identify that there are several pathways by which business model innovation may contribute to more sustainable production and consumption.

Assessing the sharing economy: analysing ecologies of business models

Boons F. (a) and Bocken N.(b)(c)
a) University of Manchester, Sustainable Consumption Institute & Alliance Manchester Business School, Crawford House, Manchester, UK
b) Lund University, IIIEE, Lund, Sweden
c) Delft University of Technology, Industrial Design Engineering, Delft, the Netherlands

Current attempts to improve the ecological and social impact of production and consumption practices build on the recognized relevance of business models. Business models are distinct ways of coordinating the provision of goods and services, and they affect the ecological impact and social sustainability of the technologies underlying that provision. This is especially true for so-called sharing business models focused on peer-to-peer-based activities of obtaining, giving, or sharing the access to goods and services, coordinated through community-based online services. Research on business models is rapidly developing. One characteristic of this work is that it tends to see business models as entities in themselves, with scant attention given to the context in which they occur. This is problematic, as the provision of a specific good or service is interlinked with others. As a result, the ecological and social impact of any business model is partially determined by the constellation of business models of which it is part. In this paper, we address this gap in the literature, by conceptualizing the economy as an ecology of business models. Building on work in organization studies and biology, we identify typical relationships between business models, ranging from competitive to mutually supportive. We also identify typical relationships between business models and their habitat, which includes physical resources and spatial embedding, but encompasses the institutional infrastructure in a given society.

Considering the user in the circular economy

Lofthouse V.A.(a)(b) and Prendeville S.(a)
a) IDI, Loughborough University, London, UK
b) Design School, Loughborough University, Loughborough, Leics, UK

This paper reflects on how much of the dialogue and literature regarding a move towards a circular economy tends to focus on production and that this language reflects a technological narrative around innovation for a future circular economy. The authors argue that there is a need for a more profound consideration of users in both the research activity and practical implementation of the circular economy, where the real needs, desires and values of the end user are incorporated from the outset, whether as part of research agendas, theories, frameworks or business models. The paper concludes by arguing that changing the way that the circular economy is framed so that it is more inclusive of the consumption side of the development process would open up greater opportunities for success.
8.1 Consumer influences

Location: Wim Crouwel room
Chair: James Pierce

Consumer perspectives on product lifetimes: a national study of lifetime satisfaction and purchasing factors
Gnanapragasam A. (a), Cooper T. (a), Cole C. (a) and Oguchi M. (b)

(a) Centre for Industrial Energy, Materials and Products, Nottingham Trent University, Nottingham, United Kingdom
(b) National Institute for Environmental Studies, Tsukuba, Japan

The extension of product lifetimes of consumer goods has the potential to encourage sustainable consumption, reduce carbon emissions and facilitate a transition to a circular economy. However, current understandings of consumer perspectives on product lifetimes are limited. This paper presents the findings of the first national study of consumer satisfaction with product lifetimes across an exhaustive range of consumer durables. The research was undertaken in the United Kingdom where consumer satisfaction and purchasing factors were studied across eighteen product categories. These product categories were devised from academic and market research undertaken at Nottingham Trent University. In total, 2,207 participants completed the survey and the sample profile was similar to the United Kingdom’s population with respect to age and gender. The results indicate that consumers appear generally satisfied with the lifetimes of their products and suggest that efforts to extend product lifetimes should focus on developing business and policy options. However, participants also emphasised that longevity, reliability and guarantee length were important factors in their purchasing decisions. Consumer interest in these factors could indicate that lifetime labelling and the promotion of longer guarantees by manufacturers and retailers may offer pathways to reduce energy and material consumption associated with short-lived products, facilitating movement towards a low carbon circular economy.

Sustainable consumption through product longevity: the influence of enhanced product lifetime information on purchasing electrical appliances among German consumers

Jacobs K. (a)

(a) Alanus University of Arts and Social Sciences, Alfter, Germany

This study addresses several research gaps by developing and empirical testing a conceptual model for purchasing longer lasting electrical appliances. The research questions are ‘What are the determinants of purchasing longer lasting electrical appliances?’ and ‘How does a product lifetime label influence purchase decisions towards electrical appliances?’ The paper follows an interdisciplinary approach by combining economic and social psychological theories. The resulting conceptual model is tested by using choice-based conjoint analysis. Thus, the influence of a product lifetime label on consumer preferences for product lifetime and other product attributes such as price, brand or energy efficiency is examined. By means of an online questionnaire, data was collected among German consumers. Overall, the study helps to better understand the main determinants of purchasing longer lasting electrical appliances and, especially, the impact of product lifetime labelling on consumer preferences. Consumers who are willing to buy longer lasting electrical appliances are identified and characterized. Moreover, insights into the role of values, social norms and perceived behavioural control factors are generated. With the aim of stimulating demand for longer lasting electrical appliances, marketers and politicians can learn from the study how to promote drivers and reduce barriers of purchasing longer lasting electrical appliances. Marketers could, for instance, improve their durability marketing by offering enhanced product lifetime information. Politicians could introduce mandatory product lifetime labels as well as educational campaigns regarding the sustainability relevance of product longevity.
8.2 Circular economy and Policy

Location: IDE Arena  
Chair: Conny Bakker

Towards more circular office fit-outs: a socio-technical descriptive framework of office fit-out processes
Casas-Arredondo M., Croxford, B. and Domenech, T.
a) The Bartlett School of Environment, Energy and Resources, University College London, London, UK

The built environment is the most resource intensive sector of the economy, accounting for a significant share of the extracted materials and the total waste generated. Within the built environment the most recurrent replacements of building materials and components take place during fit-outs, which are the process of installing interior fittings, fixtures and finishes. These materials and components are frequently replaced in non-domestic buildings, which are therefore responsible for a significant consumption of materials and a large source of waste. However, they tend to go unnoticed and unmeasured in the research about sustainable buildings. The present work aims to study this research gap and analyse the potential for fit-outs to become more sustainable. The approach of this project ties in closely to the concept of circular economy, where materials are kept at their most useful state for as long as possible. This paper provides a socio-technical descriptive framework of fit-out processes in office buildings. This descriptive framework contains a qualitative analysis of the roles and interactions of involved stakeholders regarding the material flow (based on interviews), and a quantitative material flow analysis (MFA) throughout the downstream supply chain (based on a fit-out case study). The mixed methodology used includes on-site observations, cross-examination of the corresponding design specifications or waste reports, and semi-structured interviews with the involved stakeholders. The aim of this research is to provide a grounded perspective that allows the identification of process and design improvements that support the transition towards more "circular" fit-outs. It is concluded that there are potential areas of improvement as fit-out practices show a predominantly linear tendency both for decision making and material flows.

Understanding the societal, entrepreneurship and economic aspects of developing a circular economy in cities: a case study of Coventry in the UK
Ouillon S., Dibb S. and Peck D.
a) Coventry University, Centre for Trust Peace and Social Relations, Coventry, UK  
b) Coventry University, Centre for Business in Society, Coventry, UK  
c) Delft University of Technology, Faculty of Architecture and Built Environment, Delft, the Netherlands

One of the points of agreement emerging from international environmental policy debates is that people's choices, behaviors and lifestyles will play a vital role in achieving sustainable development (Biwei, 2012; Fleischmann, 2016). There is strong evidence of the importance of a working Circular Economy (CE) to address sustainability challenges but there are different accounts and narratives in the CE literature which can cause confusion when trying to define and understand the concept. Urbanisation coupled with the fact that cities are resource inefficient (Agudela-Vera 2012) has given rise to the emergence of Circular Cities such as, Amsterdam but research to date has had a strong emphasis on the "supply side" (business, policy, science) with little attention being paid to the people or "demand side" (social, consumer). It would therefore be helpful to develop a better understanding of the role that citizens and not just City governments can play in a Circular City. To address this the paper uses an illustrative example of Coventry in the UK to examine the strategies and policy actions that drive CE relevant grass roots citizen driven practices and innovations. Through the lens of this example the paper provides insights into the role that citizens could play in developing Circular Cities through citizen driven innovation mechanisms such as social enterprise. The paper concludes that we are lacking sufficient socio-economic evidence of impact on the "demand side" and provides recommendations for further research into the social and citizen driven innovation aspects of CE relevant activities in cities.
8.3 Consumer and cultural perspectives
Location: Joost van der Grinten hall
Chair: Sonja van Dam

Is there a market for refurbished toothbrushes? An exploratory study on consumers’ acceptance of refurbishment for different product categories
Mugge R. (a), Safari I., Balkenende R. (a)
(a) Delft University of Technology, Delft, the Netherlands

Refurbishment is the process of collecting used products, assessing their condition, and replacing and/or upgrading parts in order to resell them to other consumers. Although refurbishment is increasingly seen as both economically and environmentally advantageous, it remains questionable whether consumers will accept refurbishment as a viable alternative for all sorts of product categories. In-depth interviews among 18 participants were conducted in which participants were asked to sort 30 product categories on their likelihood to accept or reject a refurbished product from this category and to elaborate on their underlying motives for this. The results revealed the following reasons for either accepting or rejecting a refurbished product for a certain category: financial, functional quality, aesthetic quality, warranty, contamination, and personalisation. Based on the type of product category (e.g., hedonic vs. functional, high vs. low involvement), these reasons are either more or less important to consumers. When designing for refurbishment, designers need to tackle the relevant reasons for the specific category in their design process to stimulate consumers to accept refurbished products.

Consumer and user acceptance in the circular economy: what are researchers missing?
Camacho-Otero, J. (a), Pettersen, I.N. (a), Boks, C. (a)
a) Department of Design, Faculty of Architecture and Design, NTNU Norwegian University of Science and Technology, Trondheim, Norway

The circular economy is a platform to transition towards a more resource efficient system. Product service systems (PSS) and remanufacturing have been proposed as strategies to achieve material decoupling. Recent studies have found that their adoption has fallen short in the business-to-consumer sector, due to lack of consumer acceptance. Literature addressing this issue has failed to provide a systematic approach to the problem. By performing a structured search on Scopus and Web of Science, 24 papers focusing on consumer and user acceptance of remanufacturing and PSS were identified. By applying qualitative research methods, the articles were analysed using six categories: problem and research questions, definitions, theoretical background, issues, methods and research gaps. Resulting from the analysis an outline for a research agenda on the topic of consumer and user acceptance of PSS and remanufactured products is suggested. Such program needs to provide a definition of consumption, consumers and users in the circular economy including their role. It should explore external factors influencing acceptance, adoption and diffusion of PSS and remanufacturing such as cultural (norms, beliefs, codes) and demographic and their interaction to each other, to guide action. Answering this questions requires tools and devices from additional fields such as anthropology and sociotechnical studies complement the contributions already made by psychology and sociology.
**8.4 Circular economy**

**Location:** Studio 23/24  
**Chair:** Ana Mestre  

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**Interdisciplinary circular economy design education through local and regional partnerships**

Williams, M.\(^{(a)}\), McDonough, M.\(^{(a)}\) and Edge, S.\(^{(a)}\)  
\(a\) University of Gloucestershire, Cheltenham, England

A review of Educational Sustainable Development (ESD) strategies has found that participatory and collaborative partnerships are the most effective for engaging students with sustainability. To enable students from Higher Education to experience and understand the relevance of the Circular Economy, as opposed to the linear economy, a series of ‘real-life’ collaborative projects have been created for Design students from Product Design, Fashion Design, Commercial Interior Design and Landscape Architecture, bridging the schools of IT Computing and Business with Art and Design. These ‘real life’ projects have been created in collaboration with local and regional charities, local Government and companies. The focus of these ‘real-life’ projects is based upon facets of the Circular Economy, such as ‘Design for Longevity’, ‘Reuse’, ‘Repair’ and ‘Recycling’, with the intention of engaging staff and students with the Circular Economy within each unit of assessment. This work is evaluated using an educational framework based upon the ESD principles, which is embedded throughout the Applied Design degree programmes, with the aim of creating engaging partnerships to improve the quality and impact of the student learning experience. This paper will describe some of the ‘real-life’ case studies, focusing upon first year Design degree students, the outcome of these projects will be discussed and reflections made. Fundamentally it is found these collaborative partnerships have the ability to empower students to become active partners in the Circular Economy and the Sustainability agenda.

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**Open and closed loops: how to teach and get students to embrace circular design**

Leube, M.\(^{(a)}\) and Walcher, D.\(^{(a)}\)  
\(a\) Salzburg University of Applied Sciences, Salzburg, Austria

Design schools, being the places were new products and services are invented and conceived are extremely important stakeholders in a much needed change towards sustainability. A circular economy is based on closed resource loops so that large volumes of finite resources (used by organizations), are captured and reused (Huber, 2000) as well as open approaches to innovation and information exemplified by the share economy and business models based on use rather than property. For the very spread of a circular economy as a concept to be successful, an open stream of information and ideas must be established. Design as a discipline needs to radically change its curriculum to help generate sustainable social and economic value and this paper is like a case-study of a curriculum that was changed from a linear to a more circular approach. In short, the authors believe that design schools –with their responsibility in educating students, who in turn shape the world of tomorrow- must move from teaching closed business models to teaching open and globally-linked ones. Another aim is to stress the importance of human factors- economical, psychological and evolutionary- in speeding up what Chesbrough calls a paradigmatic shift in innovation management (Chesbrough, 2006). Design students may be interested in greener design, but few adopt the necessary business models for such a design to be truly sustainable. In a circular economy, a business is forced „to take responsibility for the entire lives of their products“ (Kleindorfer et al. 2005, S. 487).