MATERIAL DRIVEN DESIGN FOR APPAREL AND TEXTILE PRODUCTS

Anne Louise BANG[1], Malene HARSAAE[1], Linda NYVANG[2], Xenia MIKKELSEN[3], Kirsti Reitan ANDERSEN[2] and Lykke RICARD[3]
[1]Center for Applied Research in Textiles, Design & Circularity, VIA University College, Denmark
[2]Klothing - Centre for Apparel, Textiles & Ecology Research, Royal Danish Academy, Denmark
[3]SDU Innovation and Design Engineering, University of Southern Denmark, Denmark

ABSTRACT
In this paper we demonstrate how knowledge transfer between academia and industry can take place in a collaborative and workshop-based process. We discuss how that process contributes to industrial operationalisation of research-based knowledge. The research is conducted within Project Y (2023-2026), which focuses on development of textiles made of recycled textile waste. Little research exists on material driven approaches to designing yarns and fabrics based on recycled textile fibres and how these new materials perform functionally and aesthetically. Therefore, the research project aimed to cover these knowledge gaps, and this paper discusses the research that led to the development of a material driven design model for apparel and textiles. The project consortium consists of 13 partners from academia and industry occupied with design research and materials technology, textile recycling, weaving and knitting as well as fashion, workwear and interior design. The main purpose of the collaboration is to promote the development and use of greener textiles experimenting with material driven design to investigate, develop, evaluate and eventually put recycled materials into use. In the period October 2023 to October 2024, six workshops were executed. The workshops were all based on co-creation between academic and industrial partners. Each workshop led to a new variation of a material driven design model that can support the industrial processes of apparel and textiles development. Throughout the paper we demonstrate and discuss how collaboration between academia and industry provides valuable insights and perspectives contributing to the green transformation of the fashion and textiles industry.

Keywords: Material-driven design, knowledge transfer, green transition, apparel and textiles

1 INTRODUCTION & BACKGROUND
The fashion and textile industry consumes and disposes of endless piles of resources and thus have a devastating impact on the environment [1]. The newly extended EU Eco-design directive [2] emphasises the need of long-lasting products, extended producer responsibility, repairability, and the use of recycled material to foster the necessary green transition within the fashion and textile industry. Consequently, there is a call for action and systemic changes of the current fashion and textile industry [3,4]. A motivation for change is however a pre-requisite for changing any system and although the industry is aware of the environmental rationale for change, the predominant business models are so profitable from an economic perspective that motivation may stagger. The EU Eco-design directive [2] has subsidised a burgeoning acknowledgement that system changes are needed, and that research-based knowledge can contribute to a green transition in the field of fashion and textiles.
We use a concrete case from a research project to exemplify and discuss advantages and obstacles of collaborative development and knowledge creation between academia and industry. In Project Y, 13 partners from academia and industry, covering practice experience and theoretical knowledge about design research and materials technology, textile recycling, weaving and knitting as well as fashion, workwear and interior design collaborate to investigate, develop, evaluate and eventually implement recycled materials.

The focus of the project is to spin, produce, test and benchmark yarns based on fibres from recycled textiles and local bio-based feedstock, and subsequently experiment with the properties of the yarns, prototyping and sampling knitted and woven fabrics. In parallel, the project seeks to ensure that the production of the developed yarns and fabrics is scalable, and that the yarns and fabrics may possibly be further developed into a commercial context. The implementation part is driven by evaluating the developed yarns and fabrics in material driven design workshops. The goal of the workshops is to evaluate the developed yarns and fabrics and to test the relevance and applicability of the material driven design model, MDD [5]. A close collaboration between academic and industry partners is the backbone of the entire project to obtain relevant and constructive feedback driving the project forward and securing commercial and industrial relevance together with academic substantiation.

This paper focuses specifically on the collaboration between academia and industry in development and adoption of new textiles based on recycled and local bio-based materials and thus new fibres made of these materials. A big challenge in the green transition is a change of mindset from business as usual to changes on a variety of levels. Some of these changes relate to the industry's use and disposal of resources and the industry's ability to adopt new materials. Aiming to ease the adjustment and adoption phase of these new types of fabrics, the research project has employed a material driven design model, MDD [5]. Little research exists on material driven approaches to designing yarns and fabrics based on recycled textile fibres and how these new materials perform functionally and aesthetically [e.g. 5,6,7]. The limited space in this paper does not allow us to elaborate in-depth on the theoretical conceptualisation of the material driven approach, which is closely related to new materialism [8,9] as well as materials technology [10,11].

In the following sections, we introduce the workshops and iterations that form the basis for the transfer of the material-driven design model from industrial design and product engineering to apparel and textiles design and product development. We demonstrate the significance of having a co-creation process between academia and industry as the core of a research project.

2 METHODOLOGY & ITERATIONS

The research project executed six workshops in the period October 2023 to October 2024. Each workshop gave new insights into the MDD model, which has supported us developing a material-driven design process for the industrial processes of apparel and textiles design and product development. In the periods between the workshops, the researchers analysed incoming data to evaluate and further develop the model. Data includes photos, videos and field notes from workshop sessions as well as follow-up interviews with participants. The initial two workshops had participation exclusively from academia to provide a strong methodological foundation and starting point for the collaboration between academia and industry. At the following four workshops academia and industry collaboratively experimented with different versions of MDD evaluating different types of recycled and local bio-based fibres, yarns, fabrics and textile products. To obtain and acknowledge different perspectives on the material intake and the operationality of the MDD model the workshops were executed as co-creating events. The material proposals for workshops three and four were fabrics and textile products provided by the industry partners. For workshops five and six, we used prototypes of fibres, yarns and fabrics developed in the project as our starting point for the process.

2.1 Material Driven Design (MDD)

The MDD model [5] consists of four phases exploring and evaluating the unique qualities of a material proposal, or what we call material intake, to identify use potentials and potentials for further development. The first phase, *understanding the material* is about technical and experiential characterisation. The second phase, *creating materials experience vison,* addresses the purpose of the material. The third phase, *manifesting materials experience patterns,* involves the relation to users and potential user studies. The fourth phase, *designing material/product concepts,* is about making and testing. Each phase has several questions affiliated to guide the exploration and to contribute to deliver on the aim of the phases. Having investigated the material from the four angles makes it possible to present a product or a further developed material that can undergo a new MDD process or go into product development. Originally, the model has not been developed specifically to foster an industrial green transition or even been aimed at the fashion and textile industries. It was invented to reduce and overcome a traditional long adoption phase of new materials [5,12]. In the context of this paper, a long

adoption phase of new (recycled) materials can be a barrier to optimising resource consumption in the fashion and textile industry.

2.1.1 MDD – academic rehearsal

The initial two workshops were attended exclusively by a group of researchers from academia. One academic partner was already using MDD in product engineering design research and education whereas it was new to the two academic partners from fashion and textiles design research and education. Therefore, the first workshop was used to learn about and discuss the model and align expectations in relation to the practical application of the model. In the second workshop the model was investigated using hemp yarn and fabric samples as the material proposal. Figure 1 shows the original MDD model and process images from the second workshop. The participants worked together in small groups to evaluate and describe the material through the four phases of the model. Subsequently, the groups compared their experiences and evaluated in a plenary session. These workshops led to the first version of the adapted MDD model (Figure 2, left), as several participants pointed at the complexity of the original model.

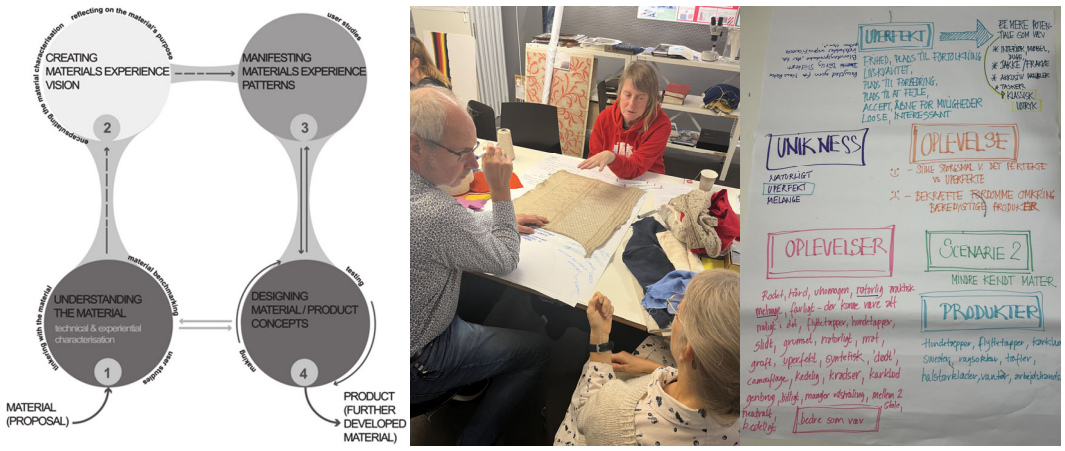

Figure 1. Left: The original MDD model. Middle and right: Academic rehearsal

2.1.2 MDD – industry trials & feedback

At the first workshop with the industry partners, the academic partners introduced the original model and the theory behind it. Following that, the participants collaboratively explored and worked with the first variation of the model (figure 2, left). The overall structure and the content of the four phases including the questions were retained to explore to which extend the original model resonated with the industry partners. The participants were divided into mixed groups of academia and industry and evaluated fabrics and textile products provided by the industry partners. The fabrics' characteristics, weight and composition were known to the participants. Some of the academic partners acted as facilitators and observed the workshop.

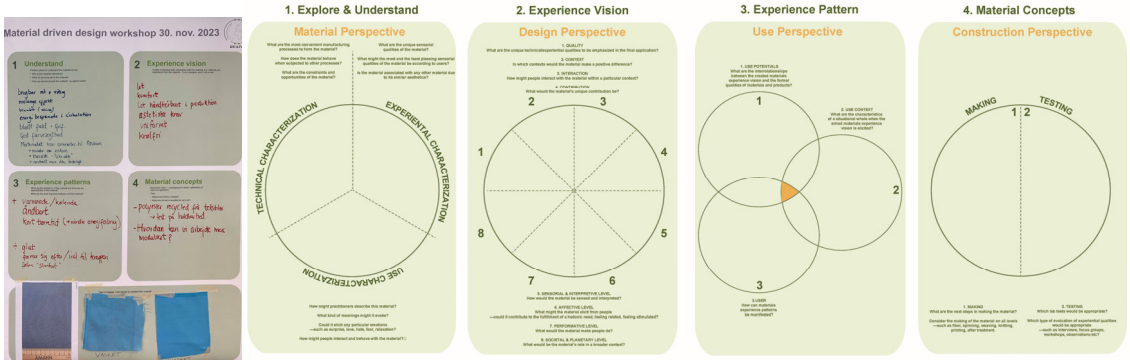

Figure 2. Left: The first adapted version of the MDD model. Right: The second adapted version of the MDD model

In between workshops, industry partners were interviewed to further elaborate on their experiences with the model and were subsequently asked to come up with their own alternative questions for the different phases of the model. Some of the important feedback included that the affiliated questions were 'too academic' and too complex and challenging to implement in the industrial practice. In between this and the following workshop with the industry partners the academic partners asked them to re-formulate the questions for a new version of the MDD model. Academia used this feedback to develop a second version of the model (figure 2, right), which guided the process and the reformulated questions. The new version retained the basic structure of the original model but experimented with an alternative visual expression and adjusted the wording of the questions associated with the four phases. The material proposals for this workshop were fabrics and yarns provided by the industry partners, but this time we did not reveal the properties to the participants. This model was received in a very positive way, but it was also mentioned that it would be difficult to implement a complex and time-consuming model like this in everyday industrial processes, even if it was helpful for evaluating materials.
This means that even though the industrial partners were positive about the changes, they still found the issues related to the four phases complex and overlapping, and the feedback indicated an overall feeling that the model in its current form would not be implemented in their industrial contexts as a tool for product development.

2.1.3 Co-creating model content between Academia and Industry

Working with models is taking place in quite different ways in academia and industry. In academia it is often used as a way to research and teach the profession's tools and processes whereas in the industry models are often used to optimise a process or a transformation. Meaning that the complexity and speed of the models are different and that there are different success criteria for a good model. In the process of developing an MDD model for apparel and textiles it became utterly important to realise this to obtain a productive result that would enable us to work with recycled fibres and local bio-based feedstock in the research project. In the research project the tasks are divided in a way that gives the academic partners the responsibility to develop the MDD model as well as planning and facilitating the workshops. During the collaborative work with MDD, we have realised that the co-creation aspect of the workshops has provided crucial value to the process. Acknowledging that the workshops and model development are co-creation on equal terms provided completely new insights, depths of understanding and knowledge building that observations and subsequent interviews had failed to uncover. The iterations and co-creating sessions between academia and industry have resulted in three new models, which all employ the original MDD model [5] as a framework for the point of departure.

2.2 Three MDD variations: co-creation between academia and industry

Following the third and fourth workshop, three models were developed. One academic partner developed an explorative questionnaire (2.2.1). At the same time, an industrial partner developed a model based on inhouse structure and procedures (2.2.2). As part of this work, the industrial partner and one academic partner had a mid-term brainstorming session to discuss their individual developments and to inspire and provide feedback for each other.). Another academic partner developed a model specific for education of fashion and textiles design students (2.2.3).

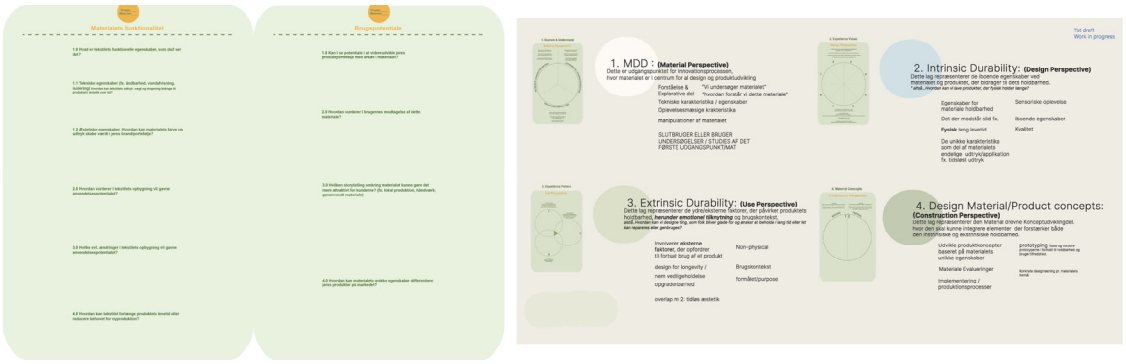

Figure 3. Left: explorative questionnaire. Right: Industrial considerations

2.2.1 From an academic model to an explorative questionnaire

The first model, a questionnaire evaluating physical samples, has been developed by one academic partner to specifically accommodate the process of evaluating the new fabrics and prototypes developed in connection with the research project (figure 3, left). At the same time, the questionnaire intends to contribute to reducing the adoption phase of new and unknown fabrics completely in line with the aim of the original model.

2.2.2 From an academic model to industrial considerations

Concurrently, one of the industrial partners within fashion developed a model specifically addressing the structure and workflow of the company (figure 3, right). Using items from the brand's basic collection to exemplify the model, insights and experiences from the co-creation sessions have contributed to the model, including introducing and implementing a perspective of intrinsic emotional durability and extrinsic emotional durability.

2.2.3 From an academic model to an educational tool

An academic partner developed an educational model with the purpose of providing fashion and textile design students with a tool enabling them to create an aesthetic operational space defined by the available materials (recycled materials, deadstock, surplus, biomaterials, etc.). The tool promotes dialogue with materials and contributes to a confrontation with the design process, dominating the industry traditionally focusing on trends and style directions (Figure 4).

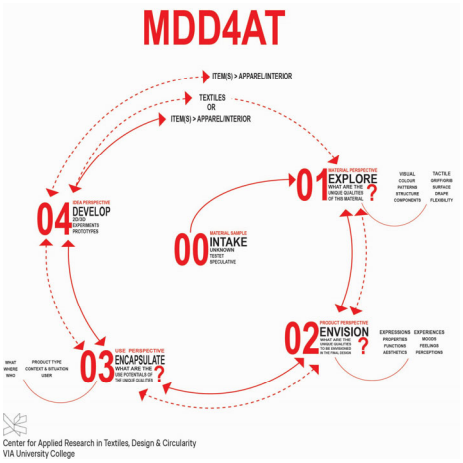

Figure 4. From academic model to educational model

This materialisation of the models demonstrates the tangible outcome of a co-creation process. In the next section we discuss the benefits of co-creation between academia and industry

3 DISCUSSIONS

As demonstrated above the co-creation in the workshop sessions have led to the development of three new models focusing on material driven design. We have identified two main findings, 1) mutual understanding and 2) open spaces of opportunity, which we will discuss in this section.

3.1 Mutual understanding: From academic theory to industrial practice

In the co-creation sessions, we experienced that what appear on paper as logic actions and easy applicable solutions for academia are both too complex and too time-consuming from commercial and industrial perspectives. The advantage of having the industry present in the developing phase of yarns and fabrics, is the immediate reaction towards new solutions and proposals. However, the commercial perspective that is often top of mind of the industry can create too fast dismissal of solutions. The design and product development processes in the apparel industry are concrete, hands-on, often under time-pressure and traditionally driven by trends and design briefs. This means that new models are best adopted if they fit into this. On the other hand, adapting new knowledge and models to fit into companies'

current work processes also carries the risk of justifying the retention of the very processes and mindsets that we are trying to change. Co-creating, developing and exploring together in interdisciplinary teams contribute to reduce the clash between commercial and academic/educational interests and improve mutual understanding of the different types of knowledge brought to the table and how these variations of knowledge can enrichen each other.

3.2 Opening spaces of opportunity through co-creation

Co-creation and feedback loops between industry and academia create spaces of opportunities to adjust models and tools to a realistic context. In this paper we have demonstrated how co-creation in interdisciplinary groups across academia and industry in the research workshops, increases the possibilities of research-based knowledge becoming active. Activating new knowledge and models together with industry partners can lead to industry feeling 'heard' instead of feeling that an approach that is not in harmony with their world is imposed on them. The challenges can be that commercial interests become too important and thus slow down the necessary green transition.

4 CONCLUDING REMARKS & REFLECTIONS

Throughout the paper we have demonstrated and discussed how interdisciplinary collaboration between academia and industry has provided valuable insights and perspectives contributing to the development of material-driven design models specifically for apparel and textiles. This is very promising, as the models contribute new approaches to the design process, which can support these industries to change mindset and thus foster the green transition. However, it can also be problematic to co-create so close, as stakeholders are biased. There is a risk that academia adapts to industry norms to a degree that industry partners are not adequately challenged. Taken to the extreme, this could mean that the necessary changes that make a real difference to the industry's green transition are not implemented. To conclude, being aware of these risks and with the intention to develop models that are activated in practice, the benefits far outweigh the disadvantages of this form of co-creation between academia and industry.

REFERENCES

[1] European Parliament (2020/2024). *The impact of textile production and waste on the environment.* https://www.europarl.europa.eu/topics/en/article/20201208STO93327/the-impact-of-textile-production-and-waste-on-the-environment-infographics [Accessed 19052025].

[2] European Union (2024). *REGULATION (EU) 2024/1781 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 13 June 2024*. In: EUR-Lex, Official Journal of the European Union, https://eur-lex.europa.eu/eli/reg/2024/1781/oj [Accessed 19052025].

[3] Deloitte & Circle Economy Foundation (2024). *The Circularity Gap Report 2024.* https://www.circularity-gap.world/2024 [Accessed 19052025].

[4] McKinsey & Company (2024). *The State of Fashion 2024: Finding pockets of growth as uncertainty reigns.* https://www.mckinsey.com/industries/retail/our-insights/state-of-fashion-2024 [Accessed 19052025].

[5] Karana E., Barati B., Rognoli V. and Zeeuw van der Laan A. (2015). Material driven design (MDD): A method to design for material experiences. *International Journal of Design,* 9(2), 35-54.

[6] Ribul M., Goldsworthy K. and Collet C. (2021). Material-Driven Textile Design (MDTD): A Methodology for Designing Circular Material-Driven Fabrication and Finishing Processes in the Materials Science Laboratory. *Sustainability* 2021, 13, 1268

[7] Mette Bak (2021). *Reintroducing Materials for Sustainable Design - Design Process and Educational Practice.* Routledge.

[8] Bennett J. (2010). *Vibrant Matter – a political ecology of things.* Duke University Press.

[9] Schwab M. (ed.) (2013). *Experimental Systems – Future Knowledge in Artistic Research*. Leuven University Press.

[10] Karana E., Pedgley O. and Rognoli V. (eds.) (2014). *Materials Experience – fundamentals of materials and design.* Butterwoth-Heinemann.

[11] Pedgley O., Rognoli V. and Karana E. (eds.) (2021). *Materials Experience 2 – expanding territories of materials and design.* Butterworth-Heinemann.

[12] Maine E., Probert D. and Ashby M. (2005). Investing in new materials: A tool for technology managers. *Technovation*, 25(1), 15-23.