PROCEEDINGS OF THE DESIGN SOCIETY

the Design Society
a worldwide community

CAMBRIDGE
UNIVERSITY PRESS

https://doi.org/10.1017/pds.2024.309 Published online by Cambridge Univer

INTERNATIONAL DESIGN CONFERENCE - DESIGN 2024

20-23 MAY 2024, CAVTAT, DUBROVNIK, CROATIA

Editors

Mario Štorga, University of Zagreb FSB, Croatia
Stanko Škec, University of Zagreb FSB, Croatia
Tomislav Martinec, University of Zagreb FSB, Croatia
Dorian Marjanović, University of Zagreb FSB, Croatia
Neven Pavković, University of Zagreb FSB, Croatia
Marija Majda Škec, University of Zagreb FSB, Croatia

Programme Committee

Scientific Advisory Board

https://doi.org/10.1017/pds.2024.309 Published online by Cambridge University Press

Bender, Beate, *Ruhr-Universität Bochum, Germany*
Benjamin, Stacy, *Northwestern University, United States of America*
Bergsjö, Dag, *Chalmers University of Technology, Sweden*
Bertoni, Alessandro, *Blekinge Institute of Technology, Sweden*
Bertoni, Marco, *Blekinge Institute of Technology, Sweden*
Blandino, Graziana, *Politecnico di Torino, Italy*
Boahen, Samuel, *Kwame Nkrumah University of Science and Technology, Ghana*
Bojčetić, Nenad, *University of Zagreb FSB, Croatia*
Bonjour, Eric, *Université de Lorraine, France*
Bordegoni, Monica, *Politecnico di Milano, Italy*
Borg, Jonathan, *University of Malta, Malta*
Borgianni, Yuri, *Free University of Bozen|Bolzano, Italy*
Boujut, Jean-Francois, *Univ. Grenoble Alpes, CNRS, Grenoble INP, G-SCOP, France*
Bouwhuis, Dominic G., *Eindhoven University of Technology, The Netherlands*
Brahma, Arindam, *Chalmers University of Technology, Sweden*
Brisco, Ross, *University of Strathclyde, United Kingdom*
Bursac, Nikola, *Hamburg University of Technology, Germany*
Bylund, Nicklas, *United States of America*
Cagan, Jonathan, *Carnegie Mellon University, United States of America*
Caldwell, Nicholas, *University of Suffolk, United Kingdom*
Calvo, Rafael A., *Imperial College London, United Kingdom*
Campean, Felician, *University of Bradford, United Kingdom*
Cantamessa, Marco, *Politecnico di Torino, Italy*
Carulli, Marina, *Politecnico di Milano, Italy*
Caruso, Giandomenico, *Politecnico di Milano, Italy*
Casakin, Hernan, *Ariel University, Israel*
Cascini, Gaetano, *Politecnico di Milano, Italy*
Cash, Philip, *Northumbria University, United Kingdom*
Chamberlain, Paul, *Sheffield Hallam University, United Kingdom*
Chantzaras, Christos, *Technical University of Munich, Germany*
Chen, Liuqing, *Zhejiang University, China*
Chiarello, Filippo, *University of Pisa, Italy*
Childs, Peter R. N., *Imperial College London, United Kingdom*
Choi, Christina Youngmi, *Royal College of Art, United Kingdom*
Chong, Leah, *Massachusetts Institute of Technology, United States of America*
Chulvi, Vicente, *Universitat Jaume I, Spain*
Ciliotta Chehade, Estefania, *Northeastern University, United States of America*
Clarkson, P. John, *University of Cambridge, United Kingdom*
Cluzel, François, *Laboratoire Genie Industriel, CentraleSupélec, Université Paris-Saclay, France*
Colombo, Samuele, *Politecnico di Torino, Italy*
Conrad, Franziska, *University of Southampton, United Kingdom*
Conrad, Jan, *Hochschule Kaiserslautern University of Applied Sciences, Germany*
Coskun, Aykut, *Koç University, Turkiye*
Coutellier, Daniel, *INSA Hauts-de-France, France*
D'Amico, Enrique, *National University of La Plata, Argentina*
Deininger, Michael, *Technical University of Denmark, Denmark*
Dekoninck, Elies Ann, *University of Bath, United Kingdom*
Del Curto, Barbara, *Politecnico di Milano, Italy*
Del Giorgio Solfa, Federico, *National University of La Plata, Argentina*
Demke, Niels, *Helmut-Schmidt-Universität/Universität der Bundeswehr Hamburg, Germany*
Eckert, Claudia, *The Open University, United Kingdom*
Ehlers, Tobias, *Gottfried Wilhelm Leibniz Universität Hannover, Germany*

https://doi.org/10.1017/pds.2024.309 Published online by Cambridge University Press

Eifler, Tobias, *Technical University of Denmark, Denmark*
Eisenbart, Boris, *Swinburne University of Technology, Australia*
Ellman, Asko Uolevi, *Tampere University, Finland*
Eneberg, Magnus, *KTH Royal Institute of Technology, Sweden*
Eppinger, Steven, *Massachusetts Institute of Technology, United States of America*
Erbe, Torsten, *ASML BV, The Netherlands*
Erden, Zuhal, *Atilim University, Turkiye*
Ericson, Åsa, *Luleå University of Technology, Sweden*
Eriksson, Yvonne, *Mälardalen University, Sweden*
Eynard, Benoit, *Université de Technologie de Compiègne, France*
Fain, Nuša, *Carleton University, Canada*
Fantoni, Gualtiero, *University of Pisa, Italy*
Fargnoli, Mario, *Universitas Mercatorum, Italy*
Farrugia, Philip, *University of Malta, Malta*
Favi, Claudio, *Università degli studi di Parma, Italy*
Fazelpour, Mohammad, *University of Maryland, United States of America*
Ferrise, Francesco, *Politecnico di Milano, Italy*
Fillingim, Kenton Blane, *Oak Ridge National Laboratory, United States of America*
Finger - CMU, Susan, *Carnegie Mellon University, United States of America*
Fiorineschi, Lorenzo, *University of Florence, Italy*
Fischer, Xavier, *ESTIA, France*
Formentini, Giovanni, *Aarhus University, Denmark*
Forte, Sven, *CONTACT Software, Germany*
Fortin, Clement, *Skolkovo Institute of Science and Technology, Russia*
Fujita, Kikuo, *Osaka University, Japan*
Gaha, Raoudha, *Université de Technologie de Compiègne, France*
Gembarski, Paul Christoph, *Leibniz Universität Hannover, Germany*
Georgiev, Georgi V., *Center for Ubiquitous Computing, University of Oulu, Finland*
Gerhard, Detlef, *Ruhr-Universität Bochum, Germany*
Gero, John, *UNC Charlotte, United States of America*
Göbel, Jens Christian, *University of Kaiserslautern-Landau, Germany*
Goker, Mehmet, *United States of America*
Gomes, Giovana Monteiro, *Technical University of Denmark, Denmark*
Gonçalves, Milene, *Delft University of Technology, The Netherlands*
Gooch, Shayne, *University of Canterbury, New Zealand*
Gopsill, James, *University of Bristol, United Kingdom*
Götz, Stefan, *Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany*
Goucher-Lambert, Kosa, *University of California, Berkeley, United States of America*
Goudswaard, Mark, *University of Bristol, United Kingdom*
Grafinger, Manfred, *TU Wien, Austria*
Graziosi, Serena, *Politecnico di Milano, Italy*
Grierson, Hilary, *University of Strathclyde, United Kingdom*
Guagliano, Mario, *Politecnico di Milano, Italy*
Guertler, Matthias R., *University of Technology Sydney, Australia*
Gunn, Wendy, *Aalborg University, Denmark*
Gupta, Ravi Kumar, *National Institute of Technical Teachers Training Bhopal, India*
Hackenberg, Georg, *University of Applied Sciences Upper Austria, Austria*
Hashemi Farzaneh, Helena, *MTU Aero Engines, Germany*
Hassannezhad, Mohammad, *Queen Mary University of London, United Kingdom*
Hatchuel, Armand, *MINES ParisTech, France*
Hehenberger, Peter, *University of Applied Sciences Upper Austria, Austria*
Hicks, Ben, *University of Bristol, United Kingdom*

https://doi.org/10.1017/pds.2024.309 Published online by Cambridge University Press

Hirz, Mario, *Graz University of Technology, Austria*
Holder, Daniel, *University of Stuttgart, Germany*
Horvat, Nikola, *University of Zagreb FSB, Croatia*
Howard, Thomas J., *Technical University of Denmark, Denmark*
Howell, Bryan, *Brigham Young University, United States of America*
Huang, Tao, *East Tennessee State University, United States of America*
Hurst, Ada, *University of Waterloo, Canada*
Husung, Stephan, *Technische Universität Ilmenau, Germany*
I. Hallstedt, Sophie, *Chalmers University of Technology, Sweden*
Iijima, Junichi, *Tokyo University of Science, Japan*
Ilies, Horea, *University of Connecticut, United States of America*
Inkermann, David, *Technische Universität Clausthal, Germany*
Ioannou Kazamia, Kika, *University of Nicosia, Cyprus*
Ion, William, *University of Strathclyde, United Kingdom*
Isaksson, Ola, *Chalmers University of Technology, Sweden*
Jagtap, Santosh, *Indian Institute of Technology Guwahati, India*
Janković, Marija, *CentraleSupélec, France*
Jean, Camille, *Arts et Métiers ParisTech, France*
Johansson, Glenn, *Lund University, Sweden*
Johansson Askling, Christian, *Blekinge Institute of Technology, Sweden*
Jowers, Iestyn, *The Open University, United Kingdom*
Jung, Eui Chul, *Seoul National University, South Korea*
Jurčević Lulić, Tanja, *University of Zagreb FSB, Croatia*
Juuti, Tero Sakari, *Tampere University, Finland*
Kattwinkel, Daniela, *Ruhr-Universität Bochum, Germany*
Keates, Simeon, *University of Chichester, United Kingdom*
Keiding, Villads, *Technical University of Denmark, Denmark*
Keldmann, Troels, *Keldmann Healthcare A/S, Denmark*
Keshwani, Sonal, *Indraprastha Institute of Information Technology, Delhi, India*
Khan, Mohammed Rajik, *National Institute of Technology Rourkela, India*
Kiessling, Jonathan Max, *University of Stuttgart, Germany*
Kim, Harrison, *University of Illinois Urbana-Champaign, United States of America*
Kim, Yong Se, *University of Turku, Finland*
Koch, Alexander, *Bundeswehr University Munich, Germany*
Koh, Edwin, *Singapore University of Technology and Design, Singapore*
Köhler, Christian, *htw saar - University of Applied Sciences, Germany*
Kokkolaras, Michael, *McGill University, Canada*
Komashie, Alexander, *University of Cambridge, United Kingdom*
Komoto, Hitoshi, *National Institute of Advanced Industrial Science and Technology (AIST), Japan*
Koronis, Georgios, *University of the Aegean, Greece*
Kota, Srinivas, *Birla Institute of Technology and Science, Pilani, India*
Kovacevic, Ahmed, *City, University of London, United Kingdom*
Krause, Dieter, *Hamburg University of Technology, Germany*
Krauss, Gordon, *Harvey Mudd College, United States of America*
Kreimeyer, Matthias, *University of Stuttgart, Germany*
Krus, Petter, *Linköping University, Sweden*
Kwak, Minjung, *Soongsil University, South Korea*
Lamé, Guillaume, *CentraleSupélec, France*
Lee, Boyeun, *University of Exeter Business School, United Kingdom*
Legaard, Jesper Falck, *Design School Kolding, Denmark*
Legardeur, Jeremy, *University of Bordeaux, ESTIA Institute of Technology, France*
Leroy, Yann, *CentraleSupélec, France*

https://doi.org/10.1017/pds.2024.309 Published online by Cambridge University Press

Li, Jamy, *Toronto Metropolitan University, Canada*
Liao, Ting, *Stevens Institute of Technology, United States of America*
Lindahl, Mattias, *Linköping University, Sweden*
Liu, Ying, *Cardiff University, United Kingdom*
Liu, Yuan, *Beijing Institute of Fashion Technology, China*
Livotov, Pavel, *Offenburg University of Applied Sciences, Germany*
López Forniés, Ignacio, *Universidad de Zaragoza, Spain*
Lugnet, Johan, *Luleå University of Technology, Sweden*
Luo, Jianxi, *Singapore University of Technology and Design, Singapore*
Mahdjoub, Morad, *Université de Technologie de Belfort-Montbéliard, France*
Maier, Anja, *University of Strathclyde, United Kingdom*
Malmqvist, Johan, *Chalmers University of Technology, Sweden*
Mandolini, Marco, *Università Politecnica delle Marche, Italy*
Maranzana, Nicolas, *Arts et Métiers ParisTech, France*
Marcocchia, Giulia, *CY école de design, France*
Marconi, Marco, *Università degli Studi della Tuscia, Italy*
Marini, Michele, *Technical University of Denmark, Denmark*
Marjanović, Dorian, *University of Zagreb FSB, Croatia*
Martinec, Tomislav, *University of Zagreb FSB, Croatia*
Marxt, Christian, *ETH Zurich, Switzerland*
Masclet, Cédric, *Univ. Grenoble Alpes, CNRS, Grenoble INP, G-SCOP, France*
Maselli, Vincenzo, *Sapienza Università di Roma, Italy*
Matsumae, Akane, *Kyushu University, Japan*
Matthews, Jason Anthony, *University of the West of England, United Kingdom*
Maurya, Santosh Kumar, *Hitachi, Ltd., Japan*
McAloone, Tim, *Technical University of Denmark, Denmark*
McKay, Alison, *University of Leeds, United Kingdom*
Menshenin, Yaroslav, *Université Grenoble Alpes, Grenoble INP, France*
Merlo, Christophe, *ESTIA, France*
Miehling, Jörg, *Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany*
Milčić, Diana, *University of Zagreb Faculty of Graphic Arts, Croatia*
Millet, Dominique, *SeaTech, Ecole d'ingénieurs - Université de Toulon, France*
Moehringer, Stefan, *Simon Moehringer Anlagenbau GmbH, Germany*
Moghaddam, Mohsen, *Northeastern University, United States of America*
Montagna, Francesca, *Politecnico di Torino, Italy*
Moon, Seung Ki, *Nanyang Technological University, Singapore*
Morosi, Federico, *Politecnico di Milano, Italy*
Mörtl, Markus, *Technical University of Munich, Germany*
Motte, Damien, *Lund University, Sweden*
Mougaard, Krestine, *Technical University of Denmark, Denmark*
Murakami, Tamotsu, *University of Tokyo, Japan*
Ndiaye, Yakhoub, *Singapore University of Technology and Design, Singapore*
Nespoli, Oscar, *University of Waterloo, Canada*
Nicolas Perry, Nicolas, *Arts et Métiers ParisTech, France*
Nielsen, Brita Fladvad, *Norwegian University of Science and Technology, Norway*
Nizamis, Kostas, *University of Twente, The Netherlands*
Nomaguchi, Yutaka, *Osaka University, Japan*
Nordin, Axel, *Lund University, Sweden*
Oehmen, Josef, *Technical University of Denmark, Denmark*
Oh, David C., *North Carolina State University, United States of America*
Öhrwall Rönnbäck, Anna, *Luleå University of Technology, Sweden*
Ölvander, Johan, *Linköping University, Sweden*

https://doi.org/10.1017/pds.2024.309 Published online by Cambridge University Press

Onkar, Prasad, *Indian Institute of Technology Hyderabad, India*
Otsuka, Akimasa, *Sanyo-Onoda City University, Japan*
Paetzold-Byhain, Kristin, *Technische Universität Dresden, Germany*
Panarotto, Massimo, *Chalmers University of Technology, Sweden*
Papalambros, Panos Y., *University of Michigan, United States of America*
Papantonopoulos, Sotiris, *Democritus University of Thrace, Greece*
Pavković, Neven, *University of Zagreb FSB, Croatia*
Peters, Diane, *Kettering University, United States of America*
Petiot, Jean-François, *École Centrale de Nantes, France*
Pigosso, Daniela C. A., *Technical University of Denmark, Denmark*
Pinquié, Romain, *Univ. Grenoble Alpes, CNRS, Grenoble INP, G-SCOP, France*
Plaumann, Benedikt, *Hamburg University of Applied Sciences, Germany*
Pradel, Patrick, *Loughborough University, United Kingdom*
Prakash, Raghu Vasu, *Indian Institute of Technology Madras, India*
Pulm, Udo, *Hamburg University of Applied Sciences, Germany*
Purwaningrum, Lu'lu', *Universitas Sebelas Maret, Indonesia*
Quattelbaum, Bastian, *Hochschule Niederrhein University of Applied Sciences, Germany*
Qureshi, Ahmed, *University of Alberta, Canada*
Ranscombe, Charlie, *Swinburne University of Technology, Australia*
Reich, Yoram, *Tel Aviv University, Israel*
Riel, Andreas, *Grenoble INP, France*
Rohmer, Serge, *Université de Technologie de Troyes, France*
Rossi, Monica, *Politecnico di Milano, Italy*
Roth, Daniel, *University of Stuttgart, Germany*
Rotini, Federico, *University of Florence, Italy*
Royo, Marta, *Universitat Jaume I, Spain*
Ruiz-Pastor, Laura, *Universitat Jaume I, Spain*
Sakao, Tomohiko, *Linköping University, Sweden*
Sarkar, Prabir, *Indian Institute of Technology Ropar, India*
Sastre, Ricardo Marques, *Federal University of Rio Grande do Sul, Brazil*
Schabacker, Michael, *Otto von Guericke University Magdeburg, Germany*
Schaub, Harald, *University of Bamberg, Germany*
Schleich, Benjamin, *Technische Universität Darmstadt, Germany*
Schulte, Jesko, *Blekinge Institute of Technology, Sweden*
Schulze, Sven-Olaf, *INCOSE, Germany*
Seering, Warren, *Massachusetts Institute of Technology, United States of America*
Self, James, *Ulsan National Institute of Science and Technology, South Korea*
Şener, Bahar, *Middle East Technical University, Turkiye*
Shafiee, Sara, *Technical University of Denmark, Denmark*
Shea, Kristina, *ETH Zurich, Switzerland*
Silva, Arlindo, *Singapore University of Technology and Design, Singapore*
Singh, Ravindra, *Delhi Technological University, India*
Singh, Vishal, *Indian Institute of Science, Bangalore, India*
Siyam, Ghadir, *BP, Canada*
Smojver, Ivica, *University of Zagreb FSB, Croatia*
Snider, Chris, *University of Bristol, United Kingdom*
Song, Binyang, *Virginia Tech, United States of America*
Sosa, Ricardo, *Monash University, New Zealand*
Stal-Le Cardinal, Julie, *CentraleSupélec, France*
Stanković, Tino, *ETH Zurich, Switzerland*
Stark, Rainer G., *Technische Universität Berlin, Germany*
Stauffer, Larry Allen, *University of Idaho, United States of America*

https://doi.org/10.1017/pds.2024.309 Published online by Cambridge University Press

Stechert, Carsten, *Ostfalia University of Applied Sciences, Germany*
Steinert, Martin, *Norwegian University of Science and Technology, Norway*
Stetter, Ralf, *RWU University of Applied Sciences Ravensburg-Weingarten, Germany*
Stylidis, Kostas, *Chalmers University of Technology, Sweden*
Sullivan, Brendan, *Politecnico di Milano, Italy*
Škec, Marija Majda, *University of Zagreb FSB, Croatia*
Škec, Stanko, *University of Zagreb FSB, Croatia*
Štorga, Mario, *University of Zagreb FSB, Croatia*
Tan, James Ah Kat, *Singapore*
Tavčar, Jože, *Lund University, Sweden*
Thoben, Klaus-Dieter, *Universität Bremen / BIBA, Germany*
Thoring, Katja, *Technical University of Munich, Germany*
Tiradentes Souto, Virginia, *University of Brasilia, Brazil*
Todeti, Somasekhara Rao, *National Institute of Technology Karnataka, Surathkal, India*
Tomiyama, Tetsuo, *International Professional University of Technology in Tokyo, Japan*
Törlind, Peter, *Luleå University of Technology, Sweden*
Trauer, Jakob, *:em engineering methods AG, Germany*
Tyl, Benjamin, *APESA, France*
Udiljak, Toma, *University of Zagreb FSB, Croatia*
Umeda, Yasushi, *The University of Tokyo, Japan*
Ura, Sharifu, *Kitami Institute of Technology, Japan*
Usenyuk-Kravchuk, Svetlana, *Ural Federal University, Russia*
Valderrama Pineda, Andres Felipe, *Aalborg University, Denmark*
Valjak, Filip, *University of Zagreb Faculty of Architecture, School of Design, Croatia*
Vallet, Flore, *Laboratoire Genie Industriel, CentraleSupélec, Université Paris-Saclay, France*
Van der Loos, Mike, *The University of British Columbia, Canada*
van der Vegte, Wilhelm Frederik, *Delft University of Technology, The Netherlands*
Vareilles, Elise, *ISAE-SUPAERO, France*
Vasantha, Gokula, *Edinburgh Napier University, United Kingdom*
Vezzetti, Enrico, *Politecnico di Torino, Italy*
Vielhaber, Michael, *Saarland University, Germany*
Vietor, Thomas, *Technische Universität Braunschweig, Germany*
Vignoli, Matteo, *University of Bologna, Italy*
Vrdoljak, Milan, *University of Zagreb FSB, Croatia*
Vrolijk, Ademir-Paolo, *Government of Canada, Canada*
Vukašinović, Nikola, *University of Ljubljana, Faculty of Mechanical Engineering, Slovenia*
Vuletic, Tijana, *University of Glasgow, United Kingdom*
Wan, Fang, *Southern University of Science and Technology, China*
Wang, Yan, *Georgia Institute of Technology, United States of America*
Wang, Yue, *The Hang Seng University of Hong Kong, Hong Kong*
Wartzack, Sandro, *Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany*
Wattts, Regan, *University of Antwerp, Belgium*
Watz, Matilda, *Blekinge Institute of Technology, Sweden*
Wendrich, Robert E., *Rawshaping Technology RBSO, The Netherlands*
Wenngren, Johan, *Luleå University of Technology, Sweden*
Wever, Renee, *Linköping University, Sweden*
Whitfield, Robert Ian, *University of Strathclyde, United Kingdom*
Wynn, David, *University of Auckland, New Zealand*
Xiong, Xue, *Tongji Uiversity, China*
Yanagisawa, Hideyoshi, *The University of Tokyo, Japan*
Yannou, Bernard, *CentraleSupélec, France*
Yildirim, Unal, *Hubei University of Automotive Technology, China*

Yip, Man Hang, *University of Cambridge, United Kingdom*
Zainal Abidin, Shahriman, *Universiti Teknologi MARA, Malaysia*
Zhang, Wendy, *University of Canterbury, New Zealand*
Zhang, Yanfang, *Kyushu University, Japan*
Zhang, Zai Fang, *Shanghai University, China*
Ziegler, Martin, *Helbling Technik Bern AG, Switzerland*
Zimmermann, Markus, *Technical University of Munich, Germany*
Zolghadri, Marc, *ISAE-Supméca, France*
Zorn, Stefan, *University of Rostock, Germany*
Žeželj, Dragan, *University of Zagreb FSB, Croatia*

https://doi.org/10.1017/pds.2024.309 Published online by Cambridge University Press

INTERNATIONAL DESIGN CONFERENCE - DESIGN 2024

20-23 MAY 2024, CAVTAT, DUBROVNIK, CROATIA

TABLE OF CONTENTS

https://doi.org/10.1017/pds.2024.309 Published online by Cambridge University Press

Design Organisation, Collaboration and Management

Design Information and Knowledge

Design Methods and Tools

https://doi.org/10.1017/pds.2024.309 Published online by Cambridge University Press

https://doi.org/10.1017/pds.2024.309 Published online by Cambridge University Press

Design for Sustainability

https://doi.org/10.1017/pds.2024.309 Published online by Cambridge University Press

https://doi.org/10.1017/pds.2024.309 Published online by Cambridge University Press

https://doi.org/10.1017/pds.2024.309 Published online by Cambridge University Press

https://doi.org/10.1017/pds.2024.309 Published online by Cambridge University Press

https://doi.org/10.1017/pds.2024.309 Published online by Cambridge University Press

https://doi.org/10.1017/pds.2024.309 Published online by Cambridge University Press

https://doi.org/10.1017/pds.2024.309 Published online by Cambridge University Press

Engineering Design Practice

INTERNATIONAL DESIGN CONFERENCE – DESIGN 2024
https://doi.org/10.1017/pds.2024.129

What Italian furniture companies do towards sustainable transition? Design actions and strategies showcased during Milan Design Week 2023

Silvia Maria Gramegna ✉, Francesca Mattioli and Xue Pei

Politecnico di Milano, Italy

✉ silviamaria.gramegna@polimi.it

Abstract

Manufacturing companies find themselves at the crossroads of innovation and sustainability in an era of growing emphasis on corporate social responsibility. This paper delves into Design for Sustainability, aiming to understand the practices Italian design furniture companies are implementing towards sustainability through case studies analysis of sustainable actions (SA) showcased in Milan Design Week 2023. The study categorizes SA according to the Design for Sustainability Framework, determining their role in furniture companies' transformative learning approaches towards sustainability.

Keywords: sustainability, sustainable design, sustainable transition, furniture sector, design for sustainability

1. Introduction

Manufacturing companies navigate the intersection of innovation and sustainability in an era marked by heightened environmental concerns and a growing focus on corporate social responsibility. This study explores Design for Sustainability in the modern manufacturing landscape, specifically within the furniture sector. The aim is to understand sustainable practices and strategies implemented by Italian design furniture companies, focusing on key questions: What sustainable actions, conducted by these companies, are presented in their public communication? The research analyses a sample of Italian design furniture companies using the DfS framework by Ceschin and Gaziulusoy (2016), adapted to assess sustainability transitions and identify areas for improvement. Qualitative research, centred on case studies from Milan Design Week 2023 (MDW2023), provides insights into sustainable practices presented by leading companies on a global stage. The study employs Ceschin and Gaziulusoy's DfS framework (2016) and integrates the transformative learning framework (Sterling, 2010) to reveal how sustainable actions signify transformative learning approaches in Italian design furniture companies.
The study is part of a broader research that aims at collecting, analysing, and testing design approaches and methods for sustainable and circular transformation of Italian manufacturing in the furniture sector.

2. Research context and background knowledge

2.1. Need for actions towards a sustainable transition

In recent decades, a growing understanding of environmental issues and their repercussions has changed how people do business globally (Dai et al., 2015). Indeed, environmentally responsible organisations are more likely to connect with consumers, governments, investors, and other actors in the value chain

(Jansson, 2011). Concerning the sector analysed in this paper, manufacturing companies in the furniture sector, the sustainable transition can influence every phase of the companies' value chain. Accordingly, the literature on DfS has highlighted the need for more studies to investigate the journey of manufacturing companies in the furniture sector facing the transition toward sustainable processes and products (Bruno et al., 2022). In fact, consumers are increasingly concerned about environmental conservation to safeguard the planet's and future generations' survival. Corporate social responsibility considerably influences consumer purchasing behaviour regarding overall product quality and ecologically friendly content. In today's environment, there is a perceptible urgency among manufacturing companies in the furniture sector to align their operations with eco-centric ideals (Barbaritano, 2021). Companies are required to progressively examine and rethink their processes to reduce environmental effects, from material procurement to production practices. As manufacturers cope with this shifting terrain, various options arise, ranging from eco-friendly material innovation to incorporating circular economy ideas. New sustainability plans and related techniques should thus be aligned with company values and meet the needs of stakeholders (Epstein, 2018; Fagerlind et al., 2019). Spurred, at least in part, by these findings, an increasing number of manufacturing companies in the furniture sector in Italy are pursuing initiatives towards a sustainable transition, seeking a new synthesis between a product's relevance to consumers and its sustainability.

2.2. Italian furniture industries and sustainability challenges

The furniture sector is essential to the Italian economy because of its worth and significant part of worldwide trade; Italy is one of the world's major exporters. Regarding European furniture production and consumption, Italy (17.5 billion euros) is the largest manufacturer by value, followed by Germany (14.5 billion euros). Similarly, Germany (9.5 billion euros) and Italy (9.2 billion euros) are the largest exporters (Bruno et al., 2022). The European Union's furniture consumption is predicted to reach 68 billion euros per year, with Germany (16.8 billion euros), the United Kingdom (14.2 billion euros), and Italy (10.2 billion euros) being the leading users by value (European Commission, 2023). The sector rose to national prominence due to its proficiency in design production. Regardless of size, most businesses are small and medium-sized, and only a few can be considered large companies, with all associated benefits and drawbacks. According to Federlegno Arredo (Federlegno, 2016), environmental sustainability is now regarded as a significant competitive advantage for furniture producers, as it encourages the development of products that better suit consumer demand. The most promising path for innovation in this area today is environmental sustainability and circularity, which are inherent in product design logic. Sustainable and circular innovations lessen the environmental impact of production while allowing added value to be derived from consumer changes. According to recent studies, the Italian furniture industry still faces significant impediments to adopting CE-based sustainable practices (Silvius et al., 2021; Barbaritano & Savelli, 2020). The situation is no different in Europe than it is in Italy. Only in the last three years have leaders in the furniture sector shown a rising interest in circular inputs. This delay has been caused by a lack of regulatory coordination at the EU, national, and regional levels (Mura et al., 2020). The EU did not develop an action plan until 2020. Another significant obstacle to sustainable transitions is the view of environmental sustainability as a cost consideration (Savelli et al., 2019). According to the latest research, there are a few cases of furniture firms in the Italian landscape moving towards sustainable transition. They have adopted circular inputs from renewables or prior life cycles (reuse and recycling), low-impact procedures, and a life extension approach to products (Barbaritano & Savelli, 2020). Other practices that companies seek to follow in the next years are energy savings, the creation of low-resource-consumption manufacturing processes, and environmental criteria for supplier selection. Given the sustainability multidimensional nature, it requires the involvement of multiple levels of decision-making and the work of various actors (including public opinion), and a critical role is played by adequate levels of communication within and across companies, consumers and stakeholders (Genç, 2017). Communication strategies can influence the adoption and implementation of sustainable practices among companies. On a broader level, competitors and entrants competing for the same market position can affect the transition to sustainable strategies (Morgan et al., 2018). Global events showcasing sectorial advancements represent an opportunity to stimulate this transition towards sustainability. Accordingly, in the Italian context, events such as the Salone del Mobile and Milan Design Week (MDW), in which furniture companies are involved, represent an important showcase to stimulate the debate across companies and for involving or informing consumers about the innovations in terms of sustainability organisations are implementing.

2.3. MDW2023: Salone del Mobile and Fuorisalone

MDW is an international key event for the furniture sector that takes place yearly in Milan; it encompasses two distinct yet intertwined events: the Salone del Mobile and the Fuorisalone. Salone del Mobile, the Milan Furniture Fair, is a preeminent event within furniture and interior design; this annual trade fair is held in Milan, in April. Its primary objective is to unveil and spotlight the latest developments, trends, and innovations within furniture, home decor, and interior design. Salone del Mobile dates back to 1961, and over the years, it has evolved into a global platform which gathers furniture manufacturers, designers, architects, and interior design professionals. These stakeholders utilise the fair to showcase their new collections and products to a discerning international audience. The 2023 edition focused on the theme "Designing Tomorrow", emphasising sustainability in design through reuse, regeneration, circularity, and energy conservation. The 61st edition adopted a planet-centric approach, reflecting the commitment of both the organisers, evidenced by sustainability certifications such as ISO 20121 and adherence to the UN Global Compact, and the exhibitors (Viganò, 2023). The 2023 designs were characterised by modularity and reusability, constructed from recycled wood and cardboard, hence departing from the tradition of monumental, short-lived stands. Additionally, several exhibitors chose to repurpose setups from previous editions or opt for materials designed for straightforward disassembly and reuse. With over 2323 exhibitors participating in the 2023 edition, Salone del Mobile underscored its standing as a global design authority, attracting influential brands and pioneering designers leading the charge in sustainable design practices (Viganò, 2023). Thus, this confluence emerged as a nucleus for networking, knowledge exchange, and exploring how sustainable design can transform the industry. The week-long exhibition also encompasses numerous events held throughout Milan, known as Fuorisalone (literally translating into Outside-fair), a comprehensive showcase of creativity and design excellence, extending beyond furniture to various design-related fields. MDW involves various satellite events, presentations, and installations spreading throughout the city. City districts (e.g., Brera, Tortona, and Lambrate) become vibrant hubs for design-related activities, with showrooms, galleries, and temporary installations transforming the urban landscape. Given the broader research project we are developing, mentioned in the introduction, MDW2023 became a field research opportunity to collect data on the actions and strategies presented by leading Italian furniture manufacturers, which became case studies analysed to understand the transformations in the sector.

2.4. Background knowledge: theoretical lenses for the study

Before the data collection, the researchers identified two theoretical frameworks that later guided the interpretation of data about sustainable actions presented by companies. In this paragraph, these two frameworks are briefly presented.

2.4.1. Design for Sustainability framework

This research refers to the DfS framework developed by Ceschin and Gaziulusoy (2016), known as the "DfS Evolutionary Framework" (DfSE). This framework provides an interpretation of the evolution of structured approaches to integrate sustainability considerations into the design of products and services. The DfSE framework aims to promote sustainable practices by encouraging a shift from traditional product-centred design to a more holistic approach that includes services. Furthermore, Ceschin and Gaziulusoy (2016) discuss the concept of sustainability transitions, which involves designing more sustainable products and creating pathways for transitioning to sustainable socio-technical systems. This transition-oriented perspective recognises the need for systemic change in various sectors. The framework, rooted in a systemic perspective, extends beyond traditional product-centric models to encompass entire product-service systems, emphasising the interconnectedness of products, services, and their socio-economic contexts. Moreover, it delineates a transformative shift from a narrow technical and product-centric focus to a more comprehensive, system-level approach for environmental

https://doi.org/10.1017/pds.2024.129 Published online by Cambridge University Press

and social benefits. This evolution is characterised by two crucial dimensions: the evolution from a technology-centric to a socio-technical perspective where user practices play a fundamental role and a shift from addressing internal firm issues to changing broader socio-economic systems. Ceschin and Gaziulusoy (2016) categorised DfS approaches into four innovation levels: Product innovation, Product-Service System innovation, Spatio-Social innovation, and Socio-Technical System innovation. By mapping these approaches onto a bi-dimensional framework based on the Insular/Systemic and Technology/People axes, their framework aimed to illustrate the overarching evolution of DfS. In this research, we adopted the DfSE framework innovation levels to analyse and categorise the sustainable practices and strategies Italian furniture companies are adopting towards a sustainable transition. The framework provides a structured approach to understanding and implementing sustainability in design processes and it can be adapted to assess and categorise the sustainability transition within different levels of innovation to identify areas for further improvement as they strive for more sustainable and responsible practices.

2.4.2. Transformative Learning and Sustainability framework

The idea of transformative learning presents the educational purpose and practices to change towards sustainability at individual and organisational scales. The Transformative Learning and Sustainability (TLS) paradigm is proposed by Sterling (2010) as a conceptual framework for incorporating sustainability ideas into education. The concept emphasises the importance of transformational pedagogy in fostering cognitive comprehension and emotional and ethical engagement with sustainability concerns. Sterling contends that such transformative learning is critical for developing a resilient and adaptable mindset in environmental and societal crises (ibid.). The TLS model emphasises the value of comprehensive learning experiences that inspire learners to challenge assumptions, develop critical thinking abilities, and accept responsibility for building a more sustainable future. Individuals are more equipped to critically engage with sustainability issues, question assumptions, and develop a feeling of responsibility for creating a more sustainable and resilient world when exposed to transformative learning experiences. The TLS framework involves three stages of learning: confirmative, reformative, and transformative. These stages represent different levels of engagement with sustainability concepts and practices. Sterling's concept of conformative, reformative, and transformative learning within the TLS model outlines a developmental progression, encouraging a shift from unquestioning conformity to a profound and transformative engagement with sustainability principles. In the conformative stage, individuals function within established societal standards without critically examining them. This phase acts as a baseline, recognising the dominant paradigms. Individuals progress from conformance to the reformative stage, marked by increased awareness and a desire to challenge prevailing standards. Individuals actively seek alternatives and may adopt more sustainable practices in this setting, but these changes may not be completely revolutionary. The TLS model recognises the importance of this transitional period as learners progress from conformity to more critical involvement. Finally, the transformative stage symbolises the model's peak, in which individuals experience a dramatic shift in their perspectives, attitudes, and behaviours. This transformative learning entails a comprehensive grasp of sustainability that includes cognitive, emotional, and ethical elements. The connection between transformative learning and sustainability stems from the awareness that addressing complex and interwoven environmental and socio-economic concerns necessitates shifting individuals' perspectives, attitudes, and behaviours. Transformative learning, expressed by theorists such as Mezirow (2003) and further elaborated by researchers such as Sterling, entails a significant change in how people perceive and interpret the world. When applied to sustainability (Sterling, 2010), transformative learning aims to go beyond traditional, fact-based education to raise awareness of the interconnection of ecological, social, and economic systems.

3. Research methods

Given the exploratory and field-based nature of the study, the qualitative research employed the collection of case studies of sustainable actions and strategies presented and communicated by leading Italian manufacturing companies in the context of MDW 2023 as the primary method.

https://doi.org/10.1017/pds.2024.129 Published online by Cambridge University Press

3.1. Criteria for case study selection

Hence, in the initial phase, the research team focused on identifying the company to include as case studies in the data collection on the field. An initial list of possible companies to include in the study was developed by analysing the program of the Salone del Mobile event and integrating such analysis with information collected by revising grey literature, such as publications by leading Italian manufacturer associations such as Federlegno Arredo, and organisations playing an essential role in promoting CE, such as Symbola. The study started with a grey literature search on Salone del Mobile online repository of exhibitors (isaloni.it). The grey literature search plan encompassed several techniques, including using a customised Google search engine, targeted websites, company websites, online magazines (i.e., Dezeen, Archidaily), and expert consultations. A list of 11 companies committed to design-intensive innovation (Design Council, 2018) was compiled at this stage. The list was further narrowed by reviewing each company's website and applying the following inclusion criteria: i) those that most consistently talk about sustainability on their websites or ii) those that most strongly represent Made in Italy - also based on the grey literature review previously mentioned. The list was reduced to nine companies. The companies manufacture design-based furniture, furnishing accessories, or appliances (e.g., tables, chairs, sofas, kitchens, and accessories). A last step of reduction of the list was made by including only the companies that had both a booth at the Salone del Mobile fair and a temporary exhibition in their city showroom or other location in the Fuorisalone, narrowing down the list to six companies. This criterion was introduced to guarantee a broader opportunity for observing the practices and strategies presented by the companies in two different venues, namely the fair dedicated to sectorial expert audiences and Fuorisalone event opened to a broader public. Finally, the research team decided to include one more company represented only in Fuorisalone and not in the Salone del Mobile fair because it is an Italian manufacturer committed to sustainability that often emerged in the national databases of virtuous sustainable furniture producers. The anonymised list of companies is reported in Table 1, together with information about the companies retrieved from the Italian business and professional services portal of the Chamber of Commerce called Chamber Office (Openapi SPA Unipersonale, 2023). All the analysed companies have their headquarters in northern and central Italy; they operate on a global scale and are from medium-sized to large-sized businesses with a turnover not exceeding €350 million and less than 940 employees.

Table 1. The anonymised list of selected case studies companies for the data collection performed during Salone del Mobile 2023 (Openapi SPA Unipersonale, 2023)

Company	Manufactured products	Number of employees	Income (€)	Dimension
Company A	Furniture and furnishing accessories	150	60M	Medium/large
Company B	Contract and office furniture	140	50M	Medium
Company C	Home and office furniture, furnishing accessories, kitchens	928	340M	Large
Company D	Furniture, furnishing accessories, kitchens	710	235M	Large
Company E	Furniture and furnishing accessories	85	110M	Medium/large
Company F	Furniture and furnishing accessories	58	20M	Medium
Company G	Kitchens and furnishing accessories	166	30M	Medium

3.2. Data collection and analysis

The field data collection occurred on April 20-21, 2023, when the research team visited the stands of the selected companies at Salone del Mobile, and the showrooms opened and set up for Fuorisalone. The protocol for data collection consisted of observation of the setup to identify any references to the sustainability of the products presented. After initial observation, the team conducted brief semi-structured interviews with persons available at the booth, requesting, when possible, to speak with persons informed concerning the sustainability features of the products and the brands. The interviewed persons are mainly from the sales department (A, B, C, E, G) and the communication department (D,

https://doi.org/10.1017/pds.2024.129 Published online by Cambridge University Press

F). Interviews were conducted by the same researcher to reduce the role of bias (Bowler et al., 2017; Savelli et al., 2021) and following three guiding questions:

- How is sustainability understood in your company?
- What initiatives or actions have you undertaken in the field of sustainability?
- Which of your products is the most emblematic example of your sustainable actions?

The process was documented by taking photographs of the displays and products presented by staff during the interviews and making notes. Data collected was organised into sheets per company to summarise the main information collected about the company (e.g., text and images); the data corpus was interpreted and discussed together by the researchers, analysing any further information provided by interviewees (e.g., pamphlets, website pages) or sourced by the research team. To analyse the results, the researchers mapped the sustainable actions undertaken by each case study company by employing an analysis tool built based on the two frameworks of references for the study. In the analysis matrix (Fig. 1), the columns represent the ten DfS approaches framed by Ceschin & Gaziulusoy (2016), and the rows represent the three levels of the TLS framework as proposed by Sterling (2010): the actions collected during the field research have been positioned based on the interpretation according to the two dimensions of the DfS approaches and the transformative orders. The lower close-up view of Fig.1 depicts an example of different actions and their positioning in the scheme. The interpretation was shared and validated with experts and design researchers, part of the research group working on the broader research project this study is part of to improve the overall quality of the analysis.

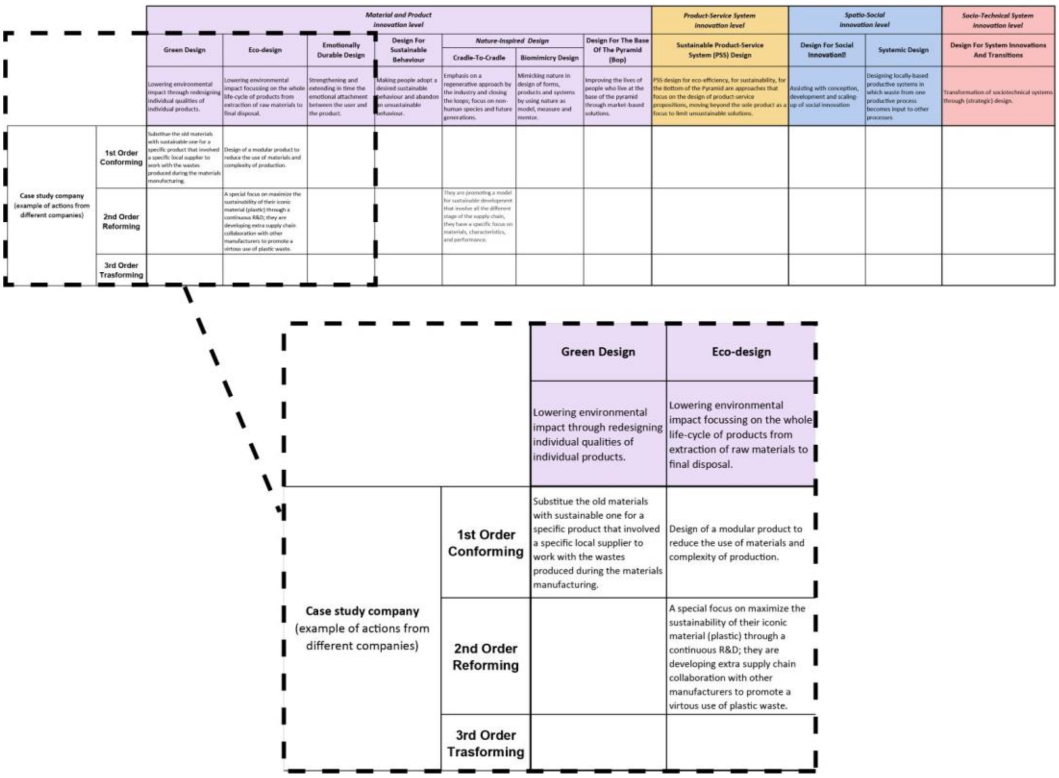

Figure 1. The analysis matrix to map the collection of sustainable actions undertaken by the case studies companies, with an example (bottom close-up view)

4. Research results

The analysis results present how Italian furniture companies carry out their sustainable actions according to the analysis matrix (Fig.1). According to the ten design approaches of the DfSE framework, the 7 Italian furniture companies have mainly presented three design approaches towards sustainability: Green Design, Eco-Design, and Cradle-to-Cradle Design. The findings around these three main DfS

https://doi.org/10.1017/pds.2024.129 Published online by Cambridge University Press

strategies are presented in the sub-sections below concerning the analysed data. The other seven approaches were not observed in the selected furniture companies during MDW2023.

4.1. Green Design approach to do things better

Three companies (i.e., A, C, F) have practised the green design approach, which aims to reduce environmental impact by redesigning individual furniture products. This approach mainly emphasises redesigning the physical product to reduce materials and resources and eventually limit the negative environmental impact (Ceschin & Gaziulusoy, 2016). The three companies have (re)designed their products by substituting traditional materials with recycled ones and creating durable forms and structures. For example, company F presented a chair made with recyclable materials created from the waste from one of their local suppliers. Companies are trying to change to a more sustainable way of doing their conventional business, including sustainability as part of their objectives. Therefore, in our interpretation, they mainly conduct a conformative learning approach towards sustainability, according to TLS framework, through sustainable activities to improve the efficiency of a physical product and production process. Apart from applying the green design approach to the physical products, sustainability is also addressed in the companies' communication in a relatively general way (i.e., dedicated web pages to the sustainable themes and sustainable reports). All three companies have used sustainability as an essential word in their communication during MDW2023. One typical example of practices emerging in this category is the restitution of traditional materials with recycled or recyclable ones to make furniture products. Company F launched a series of new products during MDW2023 by renewing their classic and iconic furniture pieces with recycled materials obtained from the recycling and other single-use ones, and the products are 100% recyclable. Similar cases could also be seen in companies A and C, which launched their new products made with recycled materials. Improvements in materials and product forms are an effective way to reduce the companies' environmental impact. The communication strategy of these actions also confirms this doing-things-better approach towards their sustainable transformation.

4.2. Eco-design approach to make things better

An advanced approach to Green Design is to extend the consideration of improving an individual product's performance to the entire life cycle of products, from extraction of raw materials to final disposal – Eco Design (Ceschin & Gaziulusoy, 2016; Pigosso, McAloone & Rozenfeld, 2015). This requires companies to develop knowledge related to product design, production, distribution, take-back, and disposal, and to create solutions that could reduce the negative environmental impact at different phases of a product's life cycle. The furniture companies we observed during MDW2023 have worked on this approach with different projects and actions. Three companies (i.e., D, E, F) have been identified to carry out an Eco-Design approach to achieve sustainability through design for product material efficiency, product design for reliability and durability, and product design for standardisation and modularity (Bocken et.al., 2016). Company D has followed the required regulations on raw material certification and European furniture products' toxic agent level. The fundamental design principle is to improve the furniture's durability. The company has made its whole production line very efficient and adapted it to avoid overproduction in advance and make the best use of available materials: do things better. Company F launched a very successful sofa designed for standardisation and modularity to reduce the use of materials and the complexity of production. The product has presented a solution considering reducing material inputs, simplifying product configuration, various product combinations, and end-of-life product disposal. In our interpretation, the sustainable actions of companies D and F are positioned at a conformative transition level as they aim to do things better, according to TLS framework. The applied design strategies have created unique and attractive solutions for consumers. Company E paid great attention to the materials: certified wood, reused or reusable plastics, and reused fabrics for making their furniture pieces to guarantee the low environmental impact of their products. Besides, the company also makes strategic partnerships with companies that produce high-end materials that give reused fabrics as the input of some components of their furniture products. Company E has developed new strategies and know-how on maximising the sustainability of their iconic material used to make furniture products and developing extra supply chain collaboration to promote a

https://doi.org/10.1017/pds.2024.129 Published online by Cambridge University Press

virtuous use of waste. From the TLS perspective, Company E has begun to change their conventional way of doing, fostering a better and more significant way to achieve sustainability instead of improving the existing ones. They have tried to understand how to reform and reshape their business offerings (i.e., products and services) through a new partnership and include sustainability as one of the parameters in the design and development process. Hence, the organisation's practices have been interpreted as reformative, according to the TLS framework.

4.3. Cradle-to-Cradle Design approach to do better things

The Cradle-to-Cradle (CTC) approach fosters radical innovation and shifts the furniture companies' business-driven mindsets towards sustainability, also considering the environmental/biological and societal aspects of the impact of furniture products and production (Ceschin & Gaziulusoy, 2016). Companies B and G have incorporated the CTC principles into their corporate missions, infusing environmental and social considerations into the design and development processes of their furniture products and services. Company B's commitment to sustainability is backed by tangible and accurate data and numbers for each product, showcasing its comprehensive approach to various sustainability issues at both the product and supply chain levels. Its sustainability department spearheads strategic initiatives, exemplified by five specific products designed for complete disassembly, enhanced durability, responsible material usage, and local sourcing. While their communication strategy remains minimal, they have employed QR codes on product displays, enabling consumers to access detailed sustainability information through the company's website. On the other hand, Company G advocates a holistic model for sustainable development that encompasses every stage of the supply chain, with a specific emphasis on materials, characteristics, and performance. Their technical approach involves addressing sustainability through material considerations, dematerialisation, and customisation systems aimed at reducing waste, minimising toxic materials, simplifying disassembly, and extending product life. Moreover, their focus extends beyond physical aspects to encompass the well-being of users, considering both ergonomic and emotional dimensions. Company G actively engages in material research, explores technological solutions, collaborates with local artisans, and designs ad hoc solutions to bolster sustainability. Company G adopts a highly focused approach in terms of communication, providing explanatory and educational materials that underscore their commitment to sustainability. The company has been dedicated to sustainability and circularity since its inception, utilising product and design solutions to narrate the compelling story of its sustainable actions effectively. The sustainable actions and strategies of companies B and G go beyond the consideration of the environmental impacts of furniture products during the whole life cycle; they tried to involve the stakeholders in the supply chains to change towards sustainability, guide their consumers to realise the meaning of sustainability and promote the social dimension of sustainability. Thanks to these actions and strategies, these two companies actively explore alternative options and embrace more sustainable practices in conventional business practices and contexts, though only partially revolutionary.

5. Discussion

Given the exploratory nature of this research, DfSE framework proves to be a valuable tool for categorising and mapping the sustainable actions showcased by Italian furniture companies during MDW2023; its combination with Sterling's TLS (2010) principles, not only facilitates a systematic examination of the companies' practices but also highlights the specific strategies employed in pursuing sustainability goals, providing a clear and insightful overview of their transformative learning orders. However, the combined framework proves somewhat generic. The study underscores the necessity of developing specific models to map and analyse distinct levels of sustainable transition through specific companies' actions, hence, identifying strategies for more effective and context-specific sustainability assessments in future research. Concerning the data collected through field research, a vast potential emerges for implementing other DfS approaches in the furniture sector. In detail, based on our analysis, a quite limited panorama of undertaken actions and DfS approaches employed by companies emerged from the MDW2023. As presented in the previous paragraphs, most of the actions and strategies are driven by mandatory requirements and regulations by the national and European norms, underling a diffused conformative approach that indicates an early stage of transforming the companies to include

https://doi.org/10.1017/pds.2024.129 Published online by Cambridge University Press

sustainability in different aspects and dimensions of the businesses and offerings. However, some companies (i.e., B, E, G) have developed more advanced sustainable actions that underlie a reformative approach (i.e., TLS second order), meaning they are currently working on particular aspects of the complete sustainability transition to "do better things". We inquired on the reasons that might have motivated such more advanced TLS order of these companies and, notably, we understood that two main phenomena determined it: i) when the core business was built mainly on sustainable values, and ii) when the company's product has, for various reasons, been singled out by public opinion as unsustainable. For the latter point, a clear example is Company E, which had to undergo a reformative process because plastic was the brand's reference material and, in the last decades, has been increasingly perceived as unsustainable by public opinion. We associate this phenomenon with what Mezirov called the "disorienting dilemma" (Laros, 2017), a fundamental step of transformative learning because it forces to change consolidated paradigms. Moreover, looking at the DfSE framework, the actions have mainly focused on materials substitution, product redesign (e.g., components, forms), and product life cycle management. This study's most notable sustainable actions refer to previously presented good examples in the cradle-to-cradle category. The limitation of these approaches is that they often focus on individual physical furniture pieces and their performance and marginally consider other aspects of sustainability. Indeed, the right side of the DfS framework still needs to be emptied, meaning there is a vast space and opportunity for Italian furniture companies to apply and implement advanced sustainable strategies and actions. The DfSE framework provides directions and trajectories to develop more significant approaches towards sustainability. Firstly, working on user or consumer engagement to extend the emotional attachment and foster sustainable behaviour is of vast potential to develop new ways to interact with furniture. Good design could make the emotional link between users and furniture products unique and continuously grow; this will increase the duration of furniture products and enable users to search for possibilities to maintain, fix, improve, and upgrade the original products instead of purchasing new ones. Secondly, transitioning towards service logic to achieve sustainability is another promising approach to maximising eco-efficiency, creating environmentally beneficial and economically competitive solutions. This design approach enables furniture companies to change from product sellers to service providers, who offer consumers more flexible and adaptive solutions to meet their use needs (for example, subscription service for renting furniture). Thirdly, the emerging systemic design approach could foster a sustainable transition of the whole sector because it deals with interdependencies and problems facing the entire sector. The systemic design strongly emphasises a comprehensive approach, considering not just the specific furniture products but their more significant effects on the environment, society, ecology, and the stakeholders in the supply chains and actors in the territories. The systemic design approach fosters sustainability transition by promoting collaborations across various disciplines and sectors, for example, cultivating strategic partnerships to close the furniture lifecycle loop by building collaborative know-how and win-win solutions for the whole supply chain. To conclude, we need to point out few limitations of this field research. Firstly, the companies involved in this study are just a small selection within the broad sector of Italian manufacturing furniture, and therefore they can't fully represent its heterogeneous panorama. However, they are recognized leading companies and their characteristics (span of size, income, typology of production and territorial distribution) turn them into a significant sample for the study. Moreover, different companies interviewed during MDW2023 revealed a discrepancy between the communication of sustainable actions, typically handled by marketing offices, and the actual practices undertaken. Many companies presented generic information during the event, while authentic, sustainable actions were evident in product details found in brochures, websites, or specific reports. This highlights the crucial need for more authentic and impactful communication strategies, emphasising transparency and alignment between intentions and actions. There is a growing demand for effective frameworks tailored to conduct context-specific sustainability assessments, aiding companies in better positioning themselves in sustainable transitions, but also capable of enhancing the awareness of the whole companies' members towards sustainable actions. These frameworks would not only aid companies in better positioning themselves within various levels of sustainable transition but also enhance the planning and execution of future sustainable actions. Notably, companies with sustainability as their core business exception to this trend, as they inherently communicate their commitment through their products.

Acknowledgements

The research presented in this paper is part of " PE_000004 Made in Italy Circular and Sustainable (MICS)", an Extended Partnership financed by the MUR (Italian Ministry of University and Research) with EU funds under the NextGenerationEU programme. In particular, the actions described are part of the project " EcoDeCK" ECO-Design Circular Knowledge, which aims to build a portfolio of eco-design-driven strategies by collecting, analysing, and testing design approaches, methods, and tools for sustainable and circular transformation.

References

Barbaritano, M. (2021), Design for innovation and competitiveness: new opportunities in the furniture sector.

Barbaritano, M. and Savelli, E. (2020), Design and sustainability for innovation in family firms. A case study from the italian furniture sector. Piccola Impresa/Small Business (1). https://doi.org/10.14596/pisb.342

Bowler, K., Castka, P. and Balzarova, M. (2017), Understanding firms' approaches to voluntary certification: Evidence from multiple case studies in FSC certification. Journal of Business Ethics, 145, pp.441-456. https://doi.org/10.1007/s10551-015-2880-1

Bruno, D., Ferrara, M., D'Alessandro, F. and Mandelli, A., 2022. The Role of Design in the CE Transition of the Furniture Industry—The Case of the Italian Company Cassina. Sustainability, 14(15), p.9168.

Ceschin, F. and Gaziulusoy, I. (2016), Design for sustainability: An evolutionary review. in Lloyd, P. and Bohemia, E. (eds.), *Future Focused Thinking - DRS International Conference* 2016, 27 - 30 June, Brighton, United Kingdom. https://doi.org/10.21606/drs.2016.59

Dai, J., Cantor, D.E. and Montabon, F.L. (2015) How environmental management competitive pressure affects a focal firm's environmental innovation activities: A green supply chain perspective. Journal of Business Logistics, 36(3), pp.242-259. https://doi.org/10.1111/jbl.12094

Genç, R. (2017), The importance of communication in sustainability & sustainable strategies. Procedia Manufacturing, 8, pp.511-516. https://doi.org/10.1016/j.promfg.2017.02.065

Epstein, M.J. and Buhovac, A.R. (2014), Making sustainability work: Best practices in managing and measuring corporate social, environmental, and economic impacts. Berrett-Koehler Publishers.

European Commission, (2023), Eurostat Prodcom Statistics. Available at: https://ec.europa.eu/eurostat/web/prodcom (Accessed 02.11.2023).

Fagerlind, T., Stefanicki, M., Feldmann, A. and Korhonen, J. (2019), The distribution of sustainable decision-making in multinational manufacturing enterprises. Sustainability, 11(18), p. 4871. https://doi.org/10.3390/su11184871

Federlegno, S. (2016), Il Made in Italy abita il futuro. Il legno arredo verso l'economia circolare.

Jansson, J., 2011. Consumer eco-innovation adoption: assessing attitudinal factors and perceived product characteristics. Business Strategy and the Environment, 20(3), pp.192-210. https://doi.org/10.1002/bse.690

Lambert, R. and Flood, R. (2017), Understanding design-intensive innovation: a literature review. Reino Unido: Design Consul.

Laros, A. (2017), Disorienting dilemmas as a catalyst for transformative learning. In Transformative learning meets bildung (pp. 85-95). Brill.

Mezirow, J. (2003), Transformative learning as discourse. Journal of transformative education, 1(1), pp.58-63.

Morgan, T.R., Tokman, M., Richey, R.G. and Defee, C. (2018), Resource commitment and sustainability: a reverse logistics performance process model. International Journal of Physical Distribution & Logistics Management, 48(2), pp.164-182.

Mura, M., Longo, M. and Zanni, S. (2020), Circular economy in Italian SMEs: A multi-method study. Journal of Cleaner Production, 245, p.118821. https://doi.org/10.1016/j.jclepro.2019.118821

Openapi SpA Unipersonale. (2023). Ufficio Camerale - Portale di Servizi alle Imprese. Available at: https://www.ufficiocamerale.it (Accessed 10.11.2023).

Pigosso, D.C.A., McAloone, T.C. and Rozenfeld, H. (2015), Characterisation of the state-of-the-art and identification of main trends for Ecodesign Tools and Methods: Classifying three decades of research and implementation. Journal of the Indian Institute of Science, 95(4), pp.405-428.

Savelli, E., Barbaritano, M. and Bravi, L. (2019), Circular Economy and Quality Management within the Furniture Sector: an exploratory study. on Quality Innovation and Sustainability, p.61. https://doi.org/10.3390/su11113089

Silvius, G., Ismayilova, A., Sales-Vivó, V. and Costi, M. (2021), Exploring barriers for circularity in the EU furniture industry. Sustainability, 13(19), p.11072. https://doi.org/10.3390/su131911072

Sterling, S. (2010), Transformative Learning and Sustainability: sketching the conceptual ground. Learning and Teaching in Higher Education, 5, 17–33.