9-10-2023

Proceedings of IASDR 2023: Life-changing Design

Daniela De Sainz Molestina
Politecnico di Milano, daniela.desainz@polimi.it

Laura Galluzzo
Politecnico di Milano, laura.galluzzo@polimi.it

Francesca Rizzo
Politecnico di Milano, francesca.rizzo@polimi.it

Davide Spallazzo
Politecnico di Milano, davide.spallazzo@polimi.it

Citation

De Sainz Molestina, D., Galluzzo, L., Rizzo, F., and Spallazzo, D. (eds.) (2023) *Proceedings of IASDR 2023: Life-changing Design*, 9-13 October, Milan, Italy, Design Research Society. https://doi.org/doi.org/10.21606/iasdr.2023.899

THE 2023

IASDR Congress

Life-changing design

Milan 9th—13th October

PROCEEDINGS OF IASDR 2023

EDITORS:

Daniela De Sainz Molestina
Laura Galluzzo
Francesca Rizzo
Davide Spallazzo

POLITECNICO MILANO 1863

SCUOLA DEL DESIGN
DIPARTIMENTO DI DESIGN

POLI.DESIGN
FOUNDED BY POLITECNICO DI MILANO

Life-Changing Design

Proceedings of the 10th Congress of the International Association of Societies of Design Research (IASDR 2023)

EDITORS:

Daniela de Sainz Molestina
Laura Galluzzo
Francesca Rizzo
Davide Spallazzo

Proceedings of the 2023 IASDR Congress
International Association of Societies of Design Research International Congress
9 – 13 October 2023
Milan, Italy
www.iasdr2023.polimi.it

Cover and congress identity design by Daniela de Sainz Molestina
Proceedings compiled by Lenny Martinez Dominguez

Editors: Daniela de Sainz Molestina, Laura Galluzzo, Francesca Rizzo, Davide Spallazzo

ISBN 978-1-912294-59-6
https://doi.org/10.21606/iasdr.2023.899

Published by the Design Research Society
85 Great Portland Street
London, W1W 7LT
United Kingdom

IASDR 2023 Organization

General Chairs

Luisa Collina, Politecnico di Milano
Alessandro Deserti, Politecnico di Milano
Francesco Zurlo, Politecnico di Milano

Programme Chairs

Laura Galluzzo, Politecnico di Milano
Francesca Rizzo, Politecnico di Milano
Davide Spallazzo, Politecnico di Milano

Doctoral and Graduate Consortium Chairs

Paola Bertola, Politecnico di Milano
Peter Gall Krogh, Aarhus University
Anna Meroni, Politecnico di Milano
Lucia Rosa Elena Rampino, Politecnico di Milano

Doctoral and Graduate Consortium Associate Chairs
Elena Mariele Elgani, Politecnico di Milano
Clorinda Sissi Galasso, Politecnico di Milano

Pictorial Chairs

Marco Quaggiotto, Politecnico di Milano
Umberto Tolino, Politecnico di Milano

Pictorial Associate Chair
Sabrina Scuri, Politecnico di Milano

Short Paper Chairs

Erminia D'Itria, Politecnico di Milano
Silvia Maria Gramegna, Politecnico di Milano
Xue Pei, Politecnico di Milano

Short Paper Associate Chairs
Ambra Borin, Politecnico di Milano
Gianluca Carella, Politecnico di Milano

Martina Carraro, Politecnico di Milano
Laura Cipriani, Politecnico di Milano
Mattia Italia, Politecnico di Milano
Francesco Leoni, Politecnico di Milano
Claudia Mastrantoni, Politecnico di Milano
Erin MCauliffe, Politecnico di Milano
Vanessa Monna, Politecnico di Milano
Angelica Vandi, Politecnico di Milano

Theme Chairs

[Changing] Organizations and Policies

Sabrina Bresciani, Politecnico di Milano
Sabine Junginger, Lucerne University of Applied Sciences and Arts
Euiyoung Kim, Delft University of Technology
Marzia Mortati, Politecnico di Milano

[Changing] Organizations and Policies Associate Chair
Hedwidge Serot Almeras

[Changing] Products and Production

Chiara Colombi, Politecnico di Milano
Venere Ferraro, Politecnico di Milano
Markus Holzbach, Offenbach University of Art and Design
KwanMyung Kim, Ulsan National Institute of Science & Technology

[Changing] Products and Production Associate Chairs
Valentin Brück, Offenbach University of Art and Design
Kwon Hyosun, Kookmin University
Tufail Muhammad, The Hong Kong Polytechnic University
James Andrew Self, Ulsan National Institute of Science Technology
Ziyu Zhou, Offenbach University of Art and Design

Identities and [Changing] Identities

José Allard, Pontificia Universidad Católica de Chile
Anna Barbara, Politecnico di Milano
Valeria Bucchetti, Politecnico di Milano
Peter Scupelli, Carnegie Mellon

Identities and [Changing] Identities Associate Chair
Reejy Atef Abdelatty Mikhail, Politecnico di Milano

[Changing] Ecosystems

Camilo Ayala García, Libera Università di Bolzano
Cindy Kohtala, Umeå Institute of Design, Umeå University
Valentina Rognoli, Politecnico di Milano
Carlo Vezzoli, Politecnico di Milano

[Changing] Ecosystems Associate Chairs
Alessandra Caroline Canfield Petrecca, Politecnico di Milano

Hang Su, Politecnico di Milano
Sofia Duarte Poblete, Politecnico di Milano
Elena Albergati, Politecnico di Milano
Luca Alessandrini, Politecnico di Milano
Barbara Pollini, Politecnico di Milano
Alessia Romani, Politecnico di Milano

[Changing] Communities

Susana Gonzaga, Universidade da Madeira
Ki Young Nam, Korea Advanced Institute of Science & Technology
Agnese Rebaglio, Politecnico di Milano
Daniela Selloni, Politecnico di Milano

[Changing] Communities Associate Chairs
Stefana Broadbent, Politecnico di Milano
Young Ok Choi, Brunel University

[Changing] Education

Elena Caratti, Politecnico di Milano
Silvia Ferraris, Politecnico di Milano
Silke Lange, Central Saint Martins, University of the Arts London
Zang Yingchun, Tsinghua University

[Changing] Education Associate Chairs
Ingrid Calvo, Universidad de Chile
Nina Trivedi, University of the Arts London
Shencheng XU, Northeast University
Chao Zhao, Tsinghua University

[Changing] Spaces and Services

Brian Dixon, Ulster University
Davide Fassi, Politecnico di Milano
Daniela Sangiorgi, Politecnico di Milano
Lou Yongqi, Tongji University

[Changing] Spaces and Services Associate Chairs
Annalinda De Rosa, Politecnico di Milano
Francesco Vergani, Politecnico di Milano

[Changing] Interactions

Mauro A. Ceconello, Politecnico di Milano
Sangwon Lee, Yonsei University
Panos Markopoulos, Eindhoven University of Technology
Margherita Pillan, Politecnico di Milano

[Changing] Interactions Associate Chairs
Tommaso Elli, Politecnico di Milano
Chris Hamamoto, Seoul National University

[Changing] Heritage

Carlo Franzato, Pontifical Catholic University of Rio de Janeiro
Rodolfo Maffeis, Politecnico di Milano
Marco Mason, Northumbria University–Newcastle
Raffaella Trocchianesi, Politecnico di Milano

[Changing] Heritage Associate Chairs
Francesca Dolcetti, University of Essex
Rosella Locatelli, Politecnico di Milano
Umair Shafqat Malik, Politecnico di Milano
Federica Rubino, Politecnico di Milano
Elena Spadoni, Politecnico di Milano

IASDR 2023 Organizing Committee

Luisa Collina, Politecnico di Milano
Francesca Rizzo, Politecnico di Milano
Laura Galluzzo, Politecnico di Milano
Davide Spallazzo, Politecnico di Milano
Daniela de Sainz Molestina, Politecnico di Milano

IASDR Executive Board

President
Toshimasa Yamanaka, Japanese Society for the Science of Design (JSSD)

Vice president
Peter Lloyd, Design Research Society (DRS)

Secretary-General
Tek-Jin Nam, Korean Society for Design Science (KSDS)

Treasurer
Fong-Gong Wu, Chinese Institute of Design (CID)

Board Members
Martyn Evans, Design Research Society (DRS)
Byung-Keun Oh, Korean Society for Design Science (KSDS)
Kenta Ono, Japanese Society for the Science of Design (JSSD)
Tung-Jung Sung, Chinese Institute of Design (CID)

Co-opted Member
David Durling, Design Research Society (DRS)

Peer Reviewers

Mehdi A. Fallah
Elena Abbiatici
Syeda Tanveer Ahmed
Sunghee Ahn
Marco Ajovalasit
Elena Albergati
Luca Alessandrini
Anwer Ali
Noris Alice
Jose Allard
Iyad Alsabouni
Akosua Mawuse Amankwah
Mariana Amatullo
Qingfan An
Laura Anselmi
Anna Anzani
Eddie Appiah
Venanzio Arquilla
Wai Dik Au
Valentina Auricchio
Elena Aversa
Steve Awoniyi
Camilo Ayala Garcia
Mata Ayoub
Laura Badalucco
Joon Sang Baek
Margarita Maria Baena Restrepo
Ladan Bahmani
Mark Bailey
Nilanjana Bairagi
Sharmistha Banerjee
Anna Barbara
Shahidha Bari
Gabriele Barzilai
Sanem Bayar
Sandra Bedaf
Andrea Benedetti
Estelle Berger
Renato Bernasconi
Maresa Bertolo
Elisa Bertolotti
Massimo Bianchini
Tom Bieling
Arianna Bionda
Mario Bisson
Thea Blackler
Johan Blomkvist
Spyros Bofylatos
Elizabeth Boling
Natasha Bonnelame
Sofie Boons
Ambra Borin
Alessandra Bosco
Marc Boulianne
Stephen Boyd Davis
Mariana Fonseca Braga
Antonio Erlindo Braga Jr.
Frederico Braida
Sabrina Bresciani
Maria De Los Angeles Briones Rojas
Stefana Broadbent
Cara Broadley
Camen Bruno
Miguel Bruns
Valeria Bucchetti
Fabienne Bünzli
Dorothea Burato
Isadora Burmeister Dickie
Sonia Cabral Matos
Valentina Caiola
Daniela Anna Calabi
Barbara Camocini
Raquel Canaan
Alessandra Caroline Canfield Petrecca
Marita Canina
Silvia Cantalupi
Elena Caratti
Gianluca Carella
Lawrence F. Caruana
Marina Carulli
Rossana Carullo
Federica Caruso
Jose Luis Casamayor
Daria Casciani
Magdalena Cattan
Marta Elisa Cecchi
Vanessa Cesário
Sejal Changede
Amy Chen
Jing Chen
JiaYing Chew
Lin Chia-Hua
Tseng-Ping Chiu
Eun Ji Cho
Hyungjun Cho
Suji Choi
Anirban Chowdhury
Mariana Ciancia

Laura Cipriani
Adriana Cobo Corey
Alessandro Colizzi
Silvia Colombo
Alice Comi
Matteo Conti
Paola Cordera
Elisa Cordero-Jahr
Anna Cornaro
Marta Corubolo
Fiammetta Costa
Vincenzo Cristallo
Barbara de Oliveira Cruz
Silvia D'Ambrosio
Erminia D'Itria
Doriana Dal Palù
Manuel Damásio
Bharati Das
Amrita Datta
Amalia de Götzen
Juan Alfonso de la Rosa
Paola De la Sotta
Valentina De Matteo
Annalinda De Rosa
Ng Debbie
Barbara Del Curto
Mariagiovanna Di Iorio
Chiara Di Lodovico
Barbara Di Prete
Cyriel Diels
Francesca Dolcetti
Dario Donetti
Ana Paula Silveira dos Santos
Dimitra Dritsa
Wu Duan
Palak Dudani
Daniel Echeverri
Duha Engawi
Silvia Escursell
Susan Evans
Fabricio Farias Tarouco
De Luca Federico
Vaz Federico
Cinzia Ferrara
Ana Margarida Ferreira
Eleonora Fiore
Francesca Foglieni
Francesca Fontana
Elena Maria Formia
Elsa Franco Franco
Brian Franklin
Teresa Franqueira
Zhiyong Fu
Rossana Gaddi
Rosendy Galabo
Brenda García Parra
Silvia Gasparotto
Pamela Gatica
Krity Gera
Giulia Gerosa
Valentina Gianfrate
Lion Giovanni
Nandhini Giri
Leonardo Gómez Castillo
Nilton Gonçalves Gamba Junior
Sara Gonizzi Barsanti
Susana Gonzaga
Silvia Maria Gramegna
Adriana Edith Granero
Sandra Groll
Emily Groves
Francesco E. Guida
Pelin Gultekin
Simone Gumtau
Weiwei Guo
Marisela Gutierrez Lopez
Julier Guy
Young Ae Hahn
Chris Hamamoto
Eduardo Hamuy
Kim Han-Jong
Ammer Harb
Robert George Harland
Yasuyuki Hayama
Leah Heiss
Leigh-Anne Hepburn
Lorenz Herfurth
Ricardo J Hernandez
Clive Hilton
Elise Hodson
Stefan Holmlid
Fei Hu
Jun Hu
Nan Hu
Li-Ting Huang
Huang Huang Yan
Karl Hurn
Gordon Hush
Claudia Huxtable
SunMin May Hwang
Kyung Hoon Hyun
Mulder Ingrid

Farina Isabel
Yoshimune Ishikawa
Mattia Italia
Ruben Jacob-Dazarola
Shiva Ji
Yan Jin
Michael Pierre Johnson
Eui-Chul Jung
Sabine Junginger
Esther Kang
Heimin Kang
Takeo Kato
Janet Kelly
Sebastian Kernbach
Danish Khan
Ahmee Kim
Chajoong Kim
Chorong Kim
Dongwhan Kim
Kyulee Kim
Miso Kim
Yujin KIM
Sara Klohn Reader
Nobuyuki Kobayashi
Cuiting Kong
Yoori Koo
Chirumalla Koteshwar
Lia Krucken
Gwendolyn Kulick
Hyosun Kwon
Yun Kyungwon
Luiz Lagares Izidio
Anna Maria Lambri
Silke Lange
Carla Langella
Lorna Lares
Meile Le
Minh-Nguyet Le
Chiara Lecce
Brian Yu Hin Lee
Changyeob Lee
Jieun Lee
Jung-Joo Lee
Kyung-Ryong Lee
Kyungho Lee
Minha Lee
Sangsu Lee
Sungeun Lee
Sunok Lee
Zune Lee
Miikka J. Lehtonen
Francesco Leoni
Beatrice Lerma
Mortara Letizia
Melanie Levick-Parkin
Honghai Li
Zihan Li
Vittorio Linfante
Baisong Liu
Fang Liu
Helene Liu
Long Liu
Wei Liu
Simon Lockrey
Leon LOH
Richard Lombard
Emilio Lonardo
Teresa Lopes
Imbesi Lorenzo
Dirk Loyens
Catalina Loyola
Min-Yuan Ma
Shuhao Ma
Yuemei Ma
Valerie Mace
Suzanne MacLeod
Adriano Magliocco
Umair Shafqat Malik
Andrea Manciaracina
Anastasios Maragiannis
Antonio Marano
Bertoni Marco
Unanue Mariane
Ilaria Mariani
Victoria Marshall
Patrizia Marti
Rodrigo Martin-Iglesias
Mazzarello Martina
Mauro Martino
Marco Mason
Claudia Mastrantoni
Sandra Mathey García-Rada
Francesca Mattioli
Markus Mau
Anna Mazzanti
Marianne McAra
Erin McAuliffe
G. Mauricio Mejía
Michele Melazzini
Maura Mengoni
Coral Michelin
Reejy Atef Abdelatty Mikhail

Kyungbo Min
Keita Mitomi
Tomohide Mizuuchi
Fahim Mohammadi
Vanessa Monna
Carolina Montoya Rodríguez
Lee Moonhwan
Brian Morgan
Carole Morrison
Margherita Motta
Martina Motta
Najla Mouchrek
Louise Mullagh
Mia Münster
Francesca Murialdo
Ki-Young NAM
Attilio Nebuloni
Oscar Nespoli
Minqing Ni
Morelli Nicola
Christiaan Nieman Janssen
Nithikul Nimkulrat
Valentina Nisi
Sophia Njeru
Murteza Noor
Renee Noortman
Raquel Noronha
Christine O'Dell
Pedro Oliveira
Takuya Onishi
Doenja Oogjes
Bryan Orthel
Yunyu Ouyang
Siiri Paananen
Stefania Palmieri
Berto Pandolfo
Pierri Paola
Stefano Parisi
Hyoung-June Park
Hyunyim (Shera) Park
Jaewan Park
Shera Hyunyim Park
Young-Woo Park
Seungho Park-Lee
Leonardo Parra Agudelo
Irene Pasina
Anke Pasold
Luciana Pastor
Milica Pavlovic
Xue Pei
Emanuele Pellegrini
Barak Pelman
Paolo Perego
Bruno Perelli
David Perez
Nancy Perlman
Daniela Petrelli
Elena Peverada
Francesca Piredda
Sofia Poblete
Alessandro Pollini
Barbara Pollini
Lubomir Popov
Vesna Popovic
Patrick Pradel
Catia Prandi
Alison Prendiville
Zoe Prosser
Yue Qiu
Alexandra Raeva
Alejandro Ramírez Lozano
Charlie Ranscombe
Vivek Rao
Lucia Ratti
Agnese Rebaglio
Price Rebecca
Steffen Reiter
Michael Renner
Dina Riccò
Valentina Rognoli
Alessia Romani
Weihan Rong
Maiara Rosa Cencic
Emilio Rossi
Qassim Saad
Nicole Sacchetti
Noemi Sadowska
Juan Salamanca
Lara Salinas
Seo Sang-Duck
Carlos Santos
Chiara Scarpitti
Scott Schmidt
Martina Sciannamè
Peter Scupelli
Sabrina Scuri
Carla Sedini
Juhri Selamet
Daniela Selloni
Andi Setiawan
Bahareh Shahri
Xiaolin Shen

Xin Shen
Yvette Shen
Chi-Fei Shih
Moe Shimomura
Jorge Sierra-Pérez
Wouter Sluis-Thiescheffer
Wina Smeenk
Silvia Soares
Bjorn Sommer
Jun Soojin
Omar Sosa-Tzec
Álvaro Sousa
Pedro Soza Ruiz
Carlo Emilio Standoli
Michael Stead
Tim Stephens
Hang Su
Suahg Su
Qian Sun
Irina Suteu
Aleksandra Sviridova
Kim Taesun
Anna Talley
Zhengyu Tan
Kelly Tang
Shen Tao
Yuki Taoka
Virginia Tassinari
Fabio Andres Tellez
Jan Tepe
Susanna Testa
James Thorp
Pieter Tilroe
Gabriella Tisza
Cyril Tjahja
Danielle Tran
Paola Maria Trapani
Viviana Trapani
Lorena Trebbi
Kate Tregloan
Nina Trivedi
Konstantinos Tsiakas
Elena Vai
Sander Valk
Anna Vallgårda
Francesca Valsecchi
Roy van den Heuvel
Nansi Van Geetsom
Koen van Turnhout
Angelica Vandi
Philippe Vanrie
Santanu Vasant
Giasemi Vavoula
Francesco Vergani
José Vicente
Melania Vicentini
Kelly Walters
Qi Wang
Wujun Wang
Xinyi Wang
Zixuan Wang
Andrea Wechsler
Huaxin Wei
Lai Wei
Amy Winters
Jiayu Wu
Yichen Wu
Yiying Wu
Nan Xia
Yumeng Xie
Long Xu
Shencheng XU
Toshimasa Yamanaka
Hideyoshi Yanagisawa
Aria Yang
Ya-chun Yang
Zhi Yang
Xinhui Ye
Zaiqiao Ye
Tse-Yen Yeh
Zang Yingchun
JungKyoon Yoon
HoYoung Youn
Luwen Yu
Gahui Yun
Ilma Yusrina
Mariana Zafeirakopoulos
Feiran Zhang
Jun Zhang
Yi Zhang
Chao Zhao
Yang Zhao
Bing Zheng
Ling Zheng
Wenqi Zheng
Jiwei Zhou
Marco Zilvetti
Lee Zune
Henfeng Zuo

The Tenth IASDR congress. An Introductory Address from the IASDR Board

IASDR 2023 is the 10th biennial congress of IASDR, and the first to take place after the crisis of COVID-19. With this congress we re-confirm the importance of discussion and debate for the network of researchers in design, as well as the importance of developing younger researchers for the future of the Association.

The International Association for Societies of Design Research (IASDR) was established in 2005 through a collaboration of four academic societies: Chinese Institute of Design (CID), the Design Research Society (DRS), Korean Society for Design Science (KSDS) and Japanese Society for the Science of Design (JSSD).

The history of international collaboration in Design Research in the Asian region can be traced back to 1996 when JSSD organized the first Japan-China Industrial Design Symposium which was hosted by Beihang University in Beijing, 1996. This started a series of international conferences in design research known as the Asian Design Conference. Conferences took place in 1997 (Daejeon, Korea at KAIST), 1998 (Taichung, Taiwan at National Taichung University of Science and Technology), 1999 (Nagaoka, Japan at Nagaoka University of Technology), 2001 (Seoul by National Seoul University), and 2003 (Tsukuba, Japan at Tsukuba International Congress Center). At the 2003 congress – the 6th Asian Design Conference – the three Asian academic societies agreed to welcome the Design Research Society into a new association.

We thus begun the International Association of Societies of Design Research for the field of design research in 2005, in Taiwan. Since that time, we have enhanced the network of researchers and fields of design research and promoted design research education. We will continue to build this incomparable network of design research as we move towards our 2025 congress, at Tapei, Taiwan.

Our deepest thanks go to Luisa Collina, and the entire Politecnico Milano team who have worked so hard, as hosts for IASDR2023, to ensure its success. Your leadership throughout the process has been excellent and we think the result will be much appreciated by the IASDR design research community.

Toshimasa Yamanaka
President

On behalf of the IASDR Board
Peter Lloyd
Tek-Jin Nam
Fong-Gong Wu
Lin-Lin Chen
Byung-Keun Oh
Rebecca Cain
Kenta Ono

Life-Changing Design.
Introduction to the Tenth IASDR congress

The International Association of Societies of Design Research (IASDR) has long been at the forefront of advancing design research, providing an international platform for researchers, scholars, and practitioners to engage in robust discussions, share insights, and explore the ever-evolving landscape of design research. IASDR 2023, the association's 10th Congress, stands as a pivotal juncture in the trajectory of design research, offering a comprehensive perspective on its current state while charting its future directions.

Over the past decade, design research has witnessed a remarkable transformation. From its roots in aesthetic considerations and form-centric approaches, design research has evolved into a multifaceted discipline, extending its influence beyond traditional boundaries. Contemporary design literature now encompasses a wide array of facets, each addressing critical aspects of design's impact on diverse domains, including organisational culture, public policies, product development, and the creation of immersive spaces, services and systems. This transformation underscores the dynamic nature of design research, as it continuously adapts to our society's changing demands and challenges.

The central theme of IASDR 2023, "Life-Changing Design", resonates profoundly in the wake of global events, particularly the unprecedented disruptions caused by the COVID-19 pandemic. This theme invites us to reflect on the profound transformations that have unfolded and continue to reshape our world. The pandemic has brought to the forefront questions about the role of design in navigating these changes, challenging us to explore how design can facilitate adaptation, resilience, and innovation in a rapidly changing world.

IASDR 2023 has been organised and host by Politecnico di Milano, where design keeps strong roots in the made in Italy tradition and where at the same time design opens up to the new territories of design research and to the new trajectories of innovation.

IASDR 2023 encompasses an array of thematic tracks, each dedicated to exploring critical dimensions of design research. These tracks serve as focal points for discussions and investigations, providing a framework for researchers to delve into specific areas of interest.

The following thematic tracks guide our exploration:

[Changing] Organizations and Policies

This track examines the transformative potential of design in the realm of public sector organisations and policies. It aims to foster social justice and sustainability by challenging traditional notions of prosperity. Researchers investigate how design equips itself with tools, methods, and frameworks to support systemic transformation, thereby promoting well-being and addressing complex societal challenges.

[Changing] Products and Production

This track focuses on the transformation of manufacturing processes and their impact on products and

systems. It explores the proliferation of digital fabrication and digital craft, analysing their potential to revolutionise product development, sustainability, and business models. Researchers delve into how design can envision emerging materials, artefacts, and future scenarios from a sustainable perspective.

Identities and [Changing] Identities

Cultural identities and their evolution in an increasingly multicultural world take center stage in this track. Researchers delve into the roots of design's influence on identity, considering factors such as authorial identities, identity hegemony, and the implications of design on gender, class, and religion. Additionally, this track explores the role of design in translation processes, which involve revising systems, tools, and programs for communicating and preserving identity.

[Changing] Ecosystems

Addressing the imperative transition toward sustainability, this track examines how design contributes to the socio-ethical and economic dimensions of sustainability. It explores design for sustainable materials, energy, business models, and transitions, focusing on fostering positive environmental and social change.

[Changing] Communities

Community empowerment and sustainable behavioural change through design interventions are central to this track. Researchers investigate how design can enhance collaborative processes, co-design knowledge, and tools while addressing urgent public interest issues. The track emphasises shared decision-making, democratic participation, and the evolving roles of individuals, communities, and entities in supporting systemic transitions.

[Changing] Education

This track reflects on the evolving landscape of design education, recognising the complexities and challenges inherent in this domain. Researchers explore the inspirations for change in design education, the transformations it engenders, and the existing gaps and issues. This track seeks to foster clarity, identity, and adaptability in designing educational goals while embracing diversity and differentiation.

[Changing] Spaces and Services

Integrating spatial and service design to create innovative living environments and services is the central concern of this track. It explores how design interventions across various scales, from micro to macro, can drive transformative actions, enhance public participation, and guarantee inclusivity and diversity in service offerings.

[Changing] Interactions

The dynamic interplay between technology, social changes, and design forms the core of this track. Researchers investigate how digital technologies, augmented reality, virtual reality, and mixed environments impact interactions, communities, processes, and professions. This track emphasises the role of Interaction Design in shaping technology-based innovations responsive to social and contextual changes.

[Changing] Heritage

Preserving and reinterpreting cultural heritage in the face of global change is the central focus of this track. Researchers explore how design research can offer novel approaches to knowledge preservation and cultural experiences related to tangible and intangible heritage. This track seeks to activate participation dynamics that reintegrate relevant portions of cultural heritage excluded from current development paradigms.

IASDR 2023, with its overarching theme of "Life-Changing Design" and its diverse thematic tracks, presents an exceptional opportunity for researchers, scholars, and practitioners to engage with the dynamic landscape of design research. The conference serves as a platform for robust discussions, knowledge sharing, and the exploration of innovative solutions to society's complex challenges.

By examining these thematic tracks and their intersection with the central theme, “Life-Changing Design,” we aim to contribute to the ongoing dialogue surrounding design research and its transformative potential, fostering a deeper understanding of design’s role in shaping our world.

Luisa Collina
Alessandro Deserti
Francesco Zurlo

Contents

[Changing] Organizations and Policies

[Changing] Products and Production

Identities and [Changing] Identities

[Changing] Ecosystems

[Changing] Communities

[Changing] Education

[Changing] Spaces and Services

[Changing] Interactions

[Changing] Heritage

Pictorials

Short Papers

Doctoral and Postgraduate Consortium Abstracts

International Association of Societies of Design Research Congress 2023
LIFE-CHANGING DESIGN
Politecnico di Milano
9-13 October 2023

The socio-ethical influences of digital technologies in the Design of S.PSS and DE: a literature review

Canfield Petrecca, Alessandra Caroline*[a]; Vezzoli, Carlo[a]

[a] Politecnico di Milano, Milan, Italy
* alessandracaroline.canfield@polimi.it

doi.org/10.21606/iasdr.2023.415

Digital technologies have become essential in most parts of the world. Being leveraged by the covid-19 pandemic, they have been used to scale up and create new products and services in different sectors. It is a shared understanding that these disruptive technologies have caused profound changes in the structure of society and, particularly, opening discussions about ethics and democracy. The Sustainable Product-Service (S.PSS) and Distributed Economy (DE) systems models are win-win opportunities for sustainability, not only in the economic and environmental but also in the socio-ethical dimension, which is sometimes neglected. Despite the growing application of digital technologies, there are few discussions about their socio-ethical interferences with the design of S.PSS and DE. This article is a systematic literature review to map the benefits and risks of digitisation for the socio-ethical dimension in these models. The selection criteria are based on six design strategies for the socio-ethical dimension developed within a set of projects conducted by the Learning Network on Sustainability (LeNS). This study aims to understand the interaction of digital technology with the socio-ethical dimension of S.PSS and DE design, mapping and reflecting on what is presented in the articles through the strategies. As a result, the founded papers presented a diversity of disciplines, and it is suggested to reformulate the strategies and models to comprise socio-ethical issues of the digital era.

Keywords: design for sustainability; sustainable product-service system; distributed economy; digital technology

1 Introduction

Digital technologies have become essential in most parts of the world, transforming contemporary societies and have been leveraged after the quarantine caused by the pandemic of Covid-19. The necessity of remote communication increased the use of data worldwide, reaching an exchange of more than 64 zettabytes (10^{21} bytes) in 2022 (Taylor, 2022). The spending on digital technology reached $1.6 trillion in the same year (Sava, 2022). Moreover, the recent development of Artificial Intelligence (AI) technologies is considered one of history's most significant technological advances (Parker, 2018; Vincent, 2017). Nevertheless, before 2020 digitalisation was already causing discussions

about its interferences in contemporary society, especially in privacy and democracy (e.g., Han, 2017; Lanier, 2018; Zuboff, 2020). Scandals such as NSA documents leeks (Greenwald, 2013) and Cambridge Analytica's influences on the US elections (Cadwalladr & Graham-Harrison, 2018) provided concrete proof that any country is vulnerable to democratic and privacy threats. The General Data Protection Regulation (GDPR, 2016) created by the European Union in 2016 changed the course of discussions on ethics in the digital era, which must continue on this path of improvement. At the time of writing this article, 200 new applications developed with the latest AI technology have been launched in the market (GenerativeAI, 2023), and the ChatGPT AI chatbot has been blocked in Italy for privacy breaches (Pollina & Mukherjee, 2023).

Businesses have permanently appropriated new technologies to remain competitive. From steam engines to today's smart equipment, being up-to-date is essential, and new technology development is accelerating to respond to this demand. In Sustainable Product-Service Systems (S.PSS), the digitalisation process started with the advent of the Internet and data transmission efficiency in the 90s (Zheng et al., 2018). With the 4th industrial revolution, smart products and services have further evolved in connectivity and intelligence (Zheng et al., 2018). Data collected through sensors and the Internet of Things (IoT) started to be used to understand users' necessities to improve and develop innovative services and products (Li & Found, 2017; Valencia et al., 2015).

The design of S.PSS combined with Distributed Economy (DE) model is a promising strategy to diffuse sustainability for all, recognised to have win-win opportunities, thus, with economic, socio-ethical, and environmental advantages (Vezzoli et al., 2021). Therefore, these strategies are necessary to face the crises affecting all three dimensions and search for more sustainable opportunities. An S.PSS model can improve, for example, access to low or middle-income people and businesses, such as a computer in a leasing offer by the producer where the user pays a monthly plan and can have access to the product (the computer) and services (maintenance, updates) at a lower initial cost. At the same time, the producer remains in ownership of the product, increasing its interest in developing environmentally sustainable products. In the digital age, DE takes a "multi-local" structure, especially concerning knowledge-based DE (i.e., Distributed/Open Software and Distributed/Open Design) (Vezzoli et al., 2021). These are communities connected virtually, sharing and developing knowledge collaboratively. The two models can assist each other in improving their structures and sustainable advantages, such as an S.PSS offer of a computer at a lower cost for software developers and open software with a remote maintenance network for the computer.

However, there is a growing awareness of the socio-ethical implications of digital technologies, and few studies have focused on their interaction in S.PSS and DE. The existing literature reviews that address some of these three subjects, the system models, digital technologies, and socio-ethical dimension, do not focus on the intersection between them. For example, Corsini & Moultrie (2021) discuss Design for Social Sustainability for S.PSS does not approach digital technology. Pirola et al. (2020) analyse digital technologies in S.PSS but present a focus on the environmental dimension. Therefore, this article intends to understand the interactions of digital technology in the socio-ethical strategies of S.PSS and DE design. Interactions here imply positive or negative exchanges brought by digital technologies. To better understand socio-ethical benefits or risks in the design of S.PSS and DE, six design strategies developed within a set of projects conducted by the Learning Network on Sustainability (LeNS) are presented as a basis.

2 Theoretical basis

The following sub-items provide an understanding of the socio-ethical dimension in the design of S.PSS and DE for this research and definitions presented in the literature for digitisation and these models.

2.1 The socio-ethical dimension in the design of S.PSS and DE

The sustainability concept is commonly balanced between three interlinked dimensions: economic, socio-ethical, and environmental (UN, 2023). The socio-ethical dimension (or social dimension) can be approached by two pillars: equity and cohesion (Vezzoli et al., 2022). Raworth's (2012) "Social Foundation" concept further characterises what this dimension comprises. It encompasses international human rights in a framework with the following categories: food security, income, water and sanitation, health, education, energy, gender equality, social equity, voice or freedom of expression, jobs and resilience (Raworth, 2012).

Product-Service System (PSS) is an offering model that mixes products and services to meet specific customer demands (Tukker & Tischner, 2006). When the provider takes ownership of the product or is responsible for its lifecycle, the value is detached from the consumption of material resources. Therefore, the PSS is considered a win-win opportunity for the three dimensions of sustainability (becoming S.PSS), developing the provider's interest in improving the environmental sustainability of its products and services, as well as reducing acquisition and/or maintenance costs for customers, providing differentiation of this offer in the market (Vezzoli et al., 2022). Specifically in the socio-ethical dimension, the S.PSS model, thus, can improve access to its products and services in low or middle-income contexts.

Parallel to this concept, DE can be described as a local-global economic system comprised of interconnected autonomous productive units established near its final customers to provide goods and services (Chaves et al., 2019), transferring control of crucial activities towards or by the end-user, such as production, maintenance and repair (Ranjani et al.,2021; Vezzoli et al., 2021). This assists in an equalitarian distribution of control of essential activities and income and strengthens social cohesion. Combining S.PSS with DE, they complement each other, improving their structures and strengthening strategies towards more sustainable designs.

The field of Design for Sustainability has been developing practices towards all dimensions. On the Socio-Ethical dimension, Clark et al. (2006), in the Design for Sustainability project for the United Nations, provided an initial approach to the social aspects of products. Tukker & Tischner (2006) also presented social/ethical sustainability aspects of the first European Network on Sustainable Product-Service Development (SusProNet). The Learning Network on Sustainability (LeNS) - an international network of higher education institutions for developing and diffusion design for sustainability as a discipline - has diverse works in this practice and functions as a distributed knowledge research community. In this sense, the network has been compiling and sharing its knowledge on literature and practices, such as Chaves et al. (2019), that provide six principles to design S.PSS and DE for socio-ethical sustainability based on social cohesion and equity. More recently, Vezzoli et al. (2022) presented an updated version of the following S.PSS design strategies for socio-ethical sustainability:

1. Improving employment and working conditions.
2. Favouring/ Integrating low-income, weaker, and marginalised.
3. Improving equity and justice between stakeholders.

4. Improving social cohesion.
5. Empowering/ enhancing local resources.
6. Enabling/ promoting responsible, sustainable consumption.

Improving employment and working conditions (1) implies an offer to small-medium business access to equipment rather than ownership; improving and sustaining and promoting healthier and safer conditions; providing adequate hours and payment; enabling job satisfaction; ensuring training and education; avoiding alienation; involving workers in decision-making processes; considering suggestions; and collaborating with colleagues and their work.

Favouring/Integrating low-income, weaker, and marginalised (2) involves improving their quality-of-life conditions, offering users access rather than ownership or shared property and complementary services to reduce running costs (maintenance, repair, update, etc.) rather than ownership. Also, systems that have easier access to credit and which facilitate foreigners and their settling in the social context.

Improving equity and justice between stakeholders (3) is related to promoting fair partnerships and just and equitable relations with suppliers, clients, communities, and institutions.

Improving social cohesion (4) involves the development of solutions that bring together those with different characteristics and foment tolerance and convergence towards a group with common goals and values. Implies promoting systems that enable integration between neighbours, different cultures, generations, and genders; for sharing and maintaining common property among neighbours; for co-housing or coworking; and for residents to participate in developing common goods (codesign).

Empowering/enhancing local resources (5) aims to enable the protection, regeneration, and enhancement of resources and local skills, increasing the perceived value associated with cultural values and identities and improving the social well-being of their communities; to offer access and/or complementary services for equipment to benefit low-medium income local entrepreneurs and for distributed/decentralised production systems (energy generation, food production, water management, manufacturing, software development, information/ knowledge generation, design).

Enabling/ promoting responsible, sustainable consumption (6) implicates fostering the comprehension of the concept of sustainability and the design for Sustainable behaviour, with strategies to guide, sustain and ensure positive behavioural changes towards sustainability; enhancing socio-ethical sustainability, increasing stakeholder transparency, complementing offers with learning experiences, and sustainable behaviour choices; and enabling the clients to participate responsibly by involving them in decision-making.

These six strategies were applied as criteria in the literature review to find where technology interfered with socio-ethical sustainability. The method is further explained in section four.

2.2 The digital era of PSS and DE

Digitalisation is a process of converting information from analogue to digital format (Negreiro & Madiega, 2019). This format is organised into units of data (bits). Digital technologies are electronic devices, resources, and systems that aid data generation, storage, and process (Mtshalia et al., 2020). Consequently, Information Communication Technologies (ICT) are vital to its development (EU, 2023). The World Economic Forum (2023) points out five technologies as highly attached to the

contemporary digital economy: Artificial intelligence, the Internet of Things, Virtual and Augmented Reality, 3D Printing, and 5G. All these technologies impact the development of products and services and, consequently, on the design field and its competencies (Ogg, 2019).

Recently, it has been argued that these technologies disrupt the social structure, altering business operations. Through data collection, user profiling, identification of behaviours, and identification of patterns, services and products are personalised, being much more responsive (Zuboff, 2020). However, this has led users to be in a state of constant vigilance, leading to behavioural manipulations (Zuboff, 2020) and resulting in solutions subject to biases (Crawford, 2021). Nonetheless, legislation has been created and developed in different parts of the world to face these radical changes, aiming for an inclusive and democratic future. In Europe, the GDPR is activated when digital technologies involve personal data (UE, 2023). Personal data is any identifiable personal information about an individual (UE, 2023). Hence, all projects dealing with human-produced data in the European Union must demonstrate GDPR compliance.

Following these trends, PSS is increasingly applying digital technologies. Zheng et al. (2018) state that this can be assumed on three levels, progressing over time onto two axes: connectivity and intelligence. First, the model benefited from Internet use, improving communications. Around 2010, with the advent of Industry 4.0, IoT was widely adopted (Zheng et al., 2018). From 2015 until today, Valencia et al. (2015) introduced the smart PSS concept as a PSS that embraces disruptive ICT. Kuhlenkötter et al. (2017, p.1) provide a simple definition of Smart PSS as a "digital-based ecosystem of value creation characterised by high complexity, dynamics and interconnectedness among stakeholders."

Smart technology enables data collection through sensors and users' input, monitoring the device conditions and user behaviour in real-time (Negash & Sarmiento, 2023). They are mainly applied to enable the customisation of offers and the development of service innovations assisting value co-creation (Li & Found, 2017; Negash & Sarmiento, 2023; Zheng et al., 2018). It can also improve technical decision-making, enhancing control and reducing risks. Scaglione et al. (2021), when analysing the use of data in the design of products and services, structure big data into two main concepts of data science and business intelligence (BI). For the authors, data science can be composed of data generators that record user activity (smart objects, computers, etc.), big data servers where it is stored (clouds), and data mining that finds patterns and creates mathematical models (i.e., algorithms). Along with that, there are three different types of BI: business analytics, data analytics, and machine learning. The first is used to provide insights that enable strategic business decisions. Data analysis is further ahead, predicting future scenarios. In an even more advanced form of BI, these strategic decisions are made through a more accurate predictive analysis of future behaviours with machine learning (Scaglione et al., 2021). Therefore, product and service systems are increasingly using data and more advanced forms of BI for their decisions.

In DE, digital technology has been an enabler for communication, self-improvement, and open data, especially leveraging distributed knowledge systems, forming virtual communities that make their projects and information available, where anyone can study, test, modify and sell solutions based on the community knowledge (Menichinelli, 2018). For example, distributed design is a system where different actors can participate in the design of a product by sharing ideas and blueprints virtually and 3D printing it locally (Perez & Santos, 2017). Although the concept of DE is strongly related to local, in

the digital economy, this model may not be well defined geographically, and people from different parts of the world can develop a solid social cohesion and become a type of distributed system (Santos, 2019; Vezzoli, 2018), what can be perceived as multilocal. Moreover, the characteristics of virtual or multilocal communities and shared knowledge approximate the distributed knowledge system to open innovation strategy concepts. Open innovation can be described as integrating collaboration and co-creating shared value to cultivate innovation ecosystems (Curley & Salmelin, 2013). Institutions search for external, collaborative innovation where the user is seen as a participant (Curley & Salmelin, 2013).

In both models (S.PSS and DE), it is possible to see that digital technologies have created a disruption. It has changed how they work by improving connectivity and collecting user data. In PSS, the smart technology incorporated into products and services allowed a closer look at users' behaviour, allowing companies to respond better to their demands. In DE, virtual platforms shorten the distances between groups and provide a space for knowledge management.

3 Methodology

This research has a qualitative approach with an exploratory goal of the subjects through a critical literature analysis. The adopted method was based on a systematic literature review (SLR) suggested by Conforto & Amaral (2011), divided into 3 phases (input, process, and output). The diagram below represents the process with each phase:

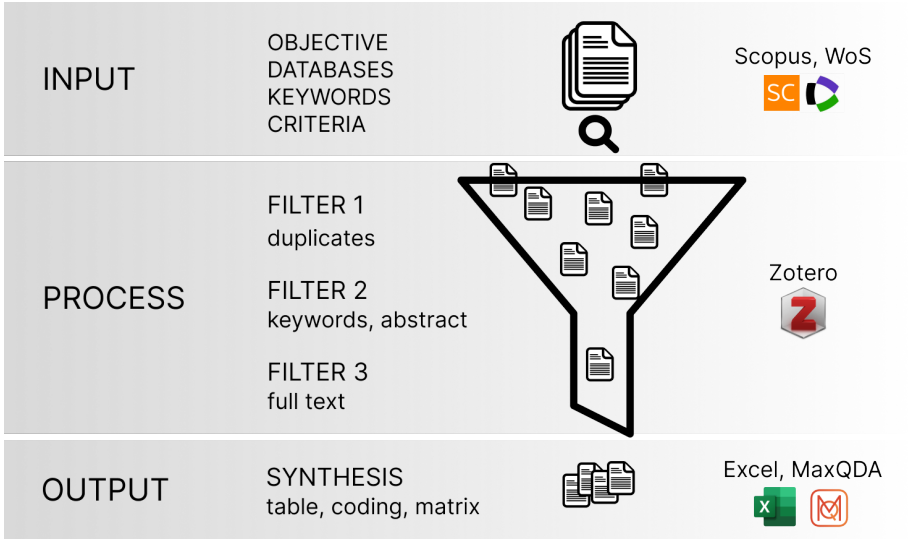

Figure 1. Literature review visual diagram.

The entry phase deals with the preparation for the research, where the objective, databases, keywords, and criteria are defined. The selection of keywords was realised through an initial literature review and the theoretical basis presented on the preview item. Therefore, the keywords representing Digital Technologies, Design for Sustainability, and Socio-Ethical Dimension compose a string to be searched in Scopus and Web of Science online databases (see Table 1).

The string brings the sequence of keywords interconnected by connectors (e.g., or, and), containing some search specifications where these words should be looked for (e.g., title). It was revised until the results shown on the first page of both sites were relevant to the subjects. In addition, some pre-

selection factors were used. For this research, peer-reviewed articles, and conferences, in English were considered. Moreover, it considered papers from the last ten years, from 2013 to 2023, focusing on more recent publications due to digital technologies' rapid development and changes. In total, eighty-nine articles were found.

In processing, the articles found in the databases were downloaded in software (Zotero) to organise and select them through three filters. First, the duplicates were deleted, as two databases were used. Next, the title, keywords, and abstract were read, seeking elements aligned with the selection criteria. Finally, the full text was read, extracting the final selection (seventeen articles).

The contents were synthesised in phase three (output), bringing the results. For this, a table (Excel) helped to compile information about articles, such as authors, year, and country. In addition, coding software (MaxQDA) was used to collect evidence to explore possible interconnections between the abovementioned strategies and the articles. For this selection of evidence, the text elements related to the strategies were attributed a weight from 1 to 3, with the paper receiving the highest number. In this classification, 1 is a citation of an element (weak evidence), 2 is an acknowledgement of some aspect, and 3 is an element inherent to the article that involves the approach (more substantial evidence). The numbers corresponding to each article in each strategy were assigned in a matrix presented in subitem 4.2.

4 Results

4.1 Systematic literature review

Through the search into the two databases, 89 articles were found. Their references were uploaded in Zotero software for control. In the second phase, the three filters were applied to sort these documents. The selection criteria were to identify evidence in the articles connected to the strategies. The articles were marked as they were related to the strategies, such as “yes” and “uncertain,” which were maintained, and “no” were then eliminated. In the first filter, 36 duplicates were eliminated, followed by the second filter, where 13 articles were eliminated. Finally, 17 remained as the final selection. Below is the string that was applied and the output of articles in each database:

Table 1. String and results in each database

String	Database	Total
(TITLE (digital* OR smart OR data* OR "artificial intelligence" OR ai OR "machine learn" OR "augmented reality" OR ar OR "internet of things" OR iot OR "virtual reality" OR vr OR 5g OR "information and communication technology" OR it OR ict OR "3D printing") AND TITLE (spss OR pss OR "product service system" OR "distributed economy" OR "decentralised economy" OR "design for sustainability" OR "open design") AND TITLE-ABS-KEY ("social sustainab*" OR socio-ethic* OR equity OR "for all" OR inclusion OR democratic OR social OR surveillanc* OR privacy OR "digital literacy" OR transparen* OR "social dimension" OR decolonial* OR pluriverse)) AND PUBYEAR > 2012 AND PUBYEAR > 2012	Scopus	53
	WoS	36

Of the selected documents, there is a slight indication of growth in the studies of these disciplines in the last ten years. However, most publications are from 2020 and 2021.

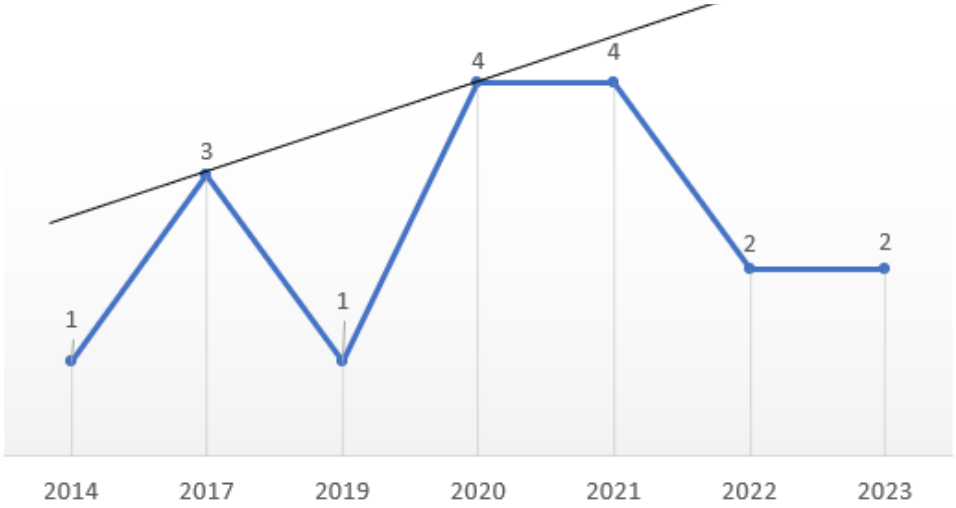

Figure 2. Graph of the publication of the selected articles per year.

In assessing the geographical location of authors and co-authors, the United Kingdom and China are the leaders, with four articles each, followed by Japan with two. Nonetheless, the selection contains a diversity of countries, with also Finland, Sweden, Swiss, Germany, Italy, USA, Equator, Turkey, Singapore, and Taiwan.

The main authors/co-authors were Ai Qiang Li and Pauline Found, with three articles each, followed by Maneesh Kumar, Pai Zheng, and Kentaro Watanabe, with two articles each. Most of the documents were from journals (11). However, the field of study was also diversified. For example, Li and Found (Li & Found, 2017) and Kumar (Li et al., 2020, 2023) have publications from the business and administration field and are strongly related to the co-creation of value through the data analysis concept. Watanabe's articles (Tsunetomo et al., 2022; Watanabe et al., 2020) are from engineering and design, bringing study cases on the development of products and services. Pai Zheng's articles (Zheng et al., 2019, 2020) are from industrial and systems engineering, discussing more general structures of smart PSS.

PSS was addressed in 14 articles, in which two mention a distributed or decentralised production type. Zheng et al. (2020) mentioned the use of Smart technologies allied with open innovation. The three articles on DE talk about forms of open knowledge, such as open design and maker communities (Beltagui et al., 2020; Cangiano et al., 2017; Menichinelli, 2017). Two mention an offer of products and services. This demonstrates the interconnection between subjects.

Furthermore, the diversity presented by the countries of the authors and fields of the journals and congresses affirms the importance of the subject since it has been approached in different disciplines and cultures.

4.2 Strategies for socio-ethical sustainability in the documents

4.2.1 Strategies matrix and benefits

For the selection of evidence, as already presented, the text elements related to the strategies were weighted from 1 to 3. The numbers corresponding to each strategy in each article were assigned in a matrix. Figure 2 represents this matrix showing the importance of each strategy per article and the strategy total score percentage as a strategy weight over the total sum of the scores:

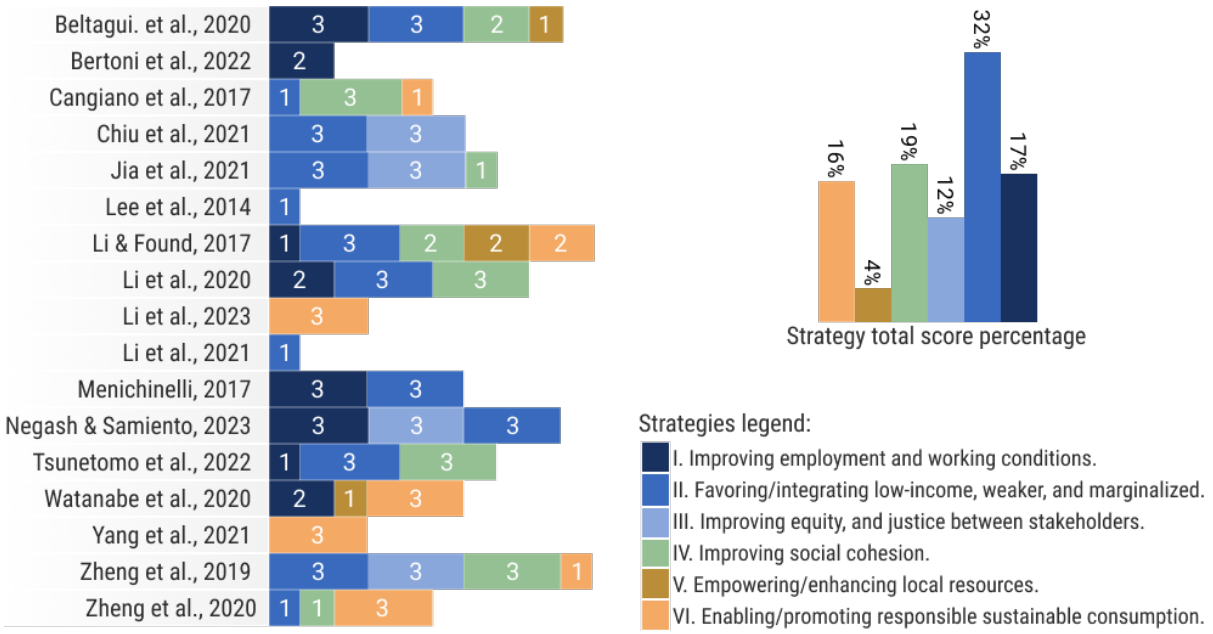

Figure 2. Evidence weight per article and strategies total score percentage.

Empowering/ enhancing local resources (5) had the fewest and weak connections (4%). In the evidence found, Beltagui et al. (2020) and Li & Found (2017) explain that the presence of local 3D printing can assist in production closer to the consumer, providing spare parts for maintenance or customised ones, allowing local stores to offer specific products and assist local workforce in delivering better maintenance services. Watanabe et al. (2020) cite a digital payment in a tourist area that provides better structure to the visitors with easy access to toilets and public baths and to purchase food and souvenirs. Conveniences like that can improve the site's attractiveness, being more prepared for new visitors who do not speak the regional language.

On the other hand, the strategies with more substantial evidence were Improving equity and justice between stakeholders (3) at 32% and Improving social cohesion (4) at 19%. A point related to DE and both strategies is the concept of open innovation described by Zheng et al. (2020) as a shared vision of different actors towards value co-creation to meet their demands, aiming for economic sustainability and well-being improvement by leveraging smart technologies to provide products and services. Menichinelli (2017) explains that digital technologies have blurred the lines between amateur and professional designers using open design platforms. Moreover, the open design enables small businesses to share resources and reduce investments (Beltagui et al., 2020; Cangiano et al., 2017).

One of the primary connections in both strategies is related to improving communication. Closer to Improving social cohesion (4) Digital technologies can engage different people in a community together through a virtual platform (Cangiano et al., 2017; Zheng et al., 2020) or connect consumers in a new channel such as a smart product for monitoring elders with a feature of video call to connect elders with their adult offspring presented in Tsunetomo et al. (2022). While more relative to Improving equity and justice between stakeholders (3), connecting providers and consumers, the idea of value co-creation through data was present in many articles (Chiu et al., 2021; Li et al., 2023; Li et al., 2021; Li & Found, 2021; Jia et al., 2021; Zheng et al.,2020; Zheng et al.,2019). From users' data collection, it is possible to obtain information to create customised services and products that better

correspond to clients' preferences and necessities (Jia et al., 2021). Li et al. (2021) claim that clients are no longer passive in the creation of value processes. Instead, they can actively participate in the process of new services, being data a bridge between stakeholders towards value co-creation. In Zheng et al. (2019), one of the definitions of smart PSS provided is an IT-driven value co-creation business, positioning this idea as a key factor for Smart PSS.

Closer to these strategies, strategy 2 for Favoring/ Integrating low-income, weaker, and marginalised was related to improving communication between client and provider. Through smart products and telemonitoring services, an S.PSS can deliver prompt remote maintenance despite users' location (Chiu et al., 2021; Jia et al., 2021; Negash & Sarmiento, 2023; Zheng et al., 2019) or remote consultancies for patients with a diverse necessity, including motion limitations such as elders (Jia et al., 2021; Negash & Samiento., 2023) with advanced remote diagnosis (Negash & Samiento, 2023). For Lee et al. (2014), data collected through these devices can also empower users by giving information about themselves and providing more control, allowing autonomy and choices.

Improving employment and working conditions (1) and Enabling/promoting responsible, sustainable consumption (6) had medium correlations found in the texts, with 16% and 17% total scores. The sixth strategy was connected to emotional design and design for sustainable behaviour. The user-affective connection was seen as an advantage for expanding the life cycle of products since it can prolong its use through personal attachment (Zheng et al., 2020; Yang et al., 2021). In Yang et al. (2021), eye-tracking data, such as pupil dilation and eye movement, was used to understand the attractiveness of a product compared to others. Another point was regulating solutions and options in response to monitoring data (Li & Found, 2017; Li et al.,2023; Zheng et al., 2019). Zheng et al. (2019) exemplify traffic regulation to reduce air pollution or provide remote maintenance to avoid physical transport of on-site services. Moreover, Li et al. (2023) mention a service of carbon calculation for customers, allowing a more conscious choice of use.

In strategy for Improving employment and working conditions (1), as smart products and services can provide information, they also can assist workers by providing better resources to execute maintenance (Li & Found, 2017; Zheng et al., 2019). Digital platforms can also assist professionals by sharing information and foment peer collaboration (Menichinelli, 2017). Another point was the use of technology to optimise work. Watanabe et al. (2020) presented a case where sensors provided data to improve exhaustive trajectories of employees in a restaurant coming and going from back to frontstage, a problem identified through a discussion with staff and managers. Some aspects of safety also arise in two other articles. For Negash & Sarmiento (2023), in the health sector, providing remote diagnosis is safer for the patient and workers due to contagious disease cases. Updating equipment can also provide safer environments, Bertoni et al. (2022) give an example of changing to electromobility with remote control in the mining industry can radically reduce air pollutants, improving workers' well-being.

4.2.2 Strategies hinders

On the negative side, a point presented in many articles was the lack of social readiness, as people do not always have access to new technologies, nor are they prepared to use them (Li et al., 2020). This was stated in the case of the involvement of elders (Jia et al., 2021; Tsunetomo et al., 2022) and in the case of workers, usually when talking about business structures (Li et al., 2020; Negash & Sarmiento, 2023; Watanabe et al., 2020). Negash & Samiento (2023) state that some patients and physicians may

become frustrated because they are not used to digital technologies. This affects strategies 1, 2, 3, and 4 as it segregates those with difficulties adapting to new technologies and who do not have access due to low income.

Despite the benefits presented by the articles being related to the exchange of large amounts of data, only four documents cited ethical concerns: Tsunetomo et al. (2022), Zheng et al. (2019), Cargiano (2017), and Menichinelli (2017). Each provided a different aspect. In developing an online platform for open design, Cargiano (2017) cites the importance of transparency and democratic processes, providing more inclusive opportunities and being especially relevant to strategies 3 and 4.

Only Tsunetomo et al. (2022) presented privacy and surveillance concerns. Nevertheless, sensors have been suggested in ten works, collecting data from the use of smart objects and services (e.g., Chiu et al., 2021; Jia et al., 2021; Lee & Kao, 2014; Li et al., 2020; Li & Found, 2017; Negash & Sarmiento, 2023; Tsunetomo et al., 2022; Watanabe et al., 2020; Yang et al., 2021; Zheng et al., 2020). In Tsunetomo et al. (2022), the authors presented a case of a monitoring service with a communication robot for elders. In a workshop with potential users, participants showed concern about the "incognito approach" function where the elderly could be watched at any time by their caretakers. Then the design was adapted to allow users to be not always observed. Furthermore, a function to enable communication between family members has been added in the interest of the value human relationships related to social cohesion (4).

Of the papers that brought the concept of data-driven value co-creation, only Zheng et al. (2019) stated concern about data collection. They mention that the design solution must follow legal restrictions such as the GDPR, ensuring awareness and consent of the collected data.

From a deeper perspective, Menichinelli (2017) goes further on the matter of data. While discussing social interaction mapping in a platform for open design, the author acknowledges the criticism of platform ecosystems regarding their influence on the social, political, and economic spheres. He cites that these interactions can affect the human relationship with knowledge, creating a preference for one type of information processing over another. The author warns that state-of-the-art technology does not necessarily mean democracy or the expression of collective intelligence. These statements can be connected to strategies 3 and 4.

5 Discussion

Although it is possible to position some of these negative impacts and relate them closer to a strategy, they may permeate and influence others, not just those associated with this paper. Furthermore, despite the positive evidence presented, many of them can be discussed from an ethical point of view. In the ten articles that presented the co-creation of value through user-generated data, this concept was seen as a promising manner to include users in the development of new solutions. Nonetheless, the use of data to develop products and services can be misleading due to bias replication presented in this data (Crawford, 2021). Moreover, it may not represent a real user will, leaving the issue of a forced desire without understanding conscious choices where the user can reflect on future actions and improve their own behaviour. Zuboff (2020) points out that one of the most significant contemporary problems is the use of excess personal data for behaviour modification and manipulation aimed at greater consumption.

In the case of the labour market, one of the biggest problems of current technology is the obsolescence of professions and professionals. Bertoni et al. (2022) and Li et al. (2017) cite the possibility of improving business structures through technology, eliminating the need for humans. Another fact is the case of the unpreparedness of users and workers, which may represent a denial of already oppressed groups who are excluded and marginalised through technology (Gonzatto & Amstel, 2022). At this point, designers may even reinforce the problem by developing products and services for idealised users, ignoring those with difficulty interacting or those without access to the web (Gonzatto & Amstel, 2022).

Lastly, in the case of Yang et al. (2021), using sensors to understand emotional and cognitive product preferences can be addressed by a more recent discussion on cognitive privacy and neural surveillance (Corbyn, 2023). The evolution of wearable devices that can collect neural activity data raises concerns that it could worsen the existing surveillance problems of digital technology.

Due to the weight of these issues and the fact that technology is generating unprecedented socio-ethical changes, a gap is identified here to reformulate the S.PSS and DE design strategies to approach these factors. These strategies should address crucial concerns such as data concentration, privacy violations, surveillance, and the potential barriers to accessing information, products, and services that threaten democratic values. Furthermore, it is important to enhance these system models to ensure they continue to benefit the socio-ethical dimension. For example, Cargiano (2017) pointed out that transparency and a democratic process could lead to more inclusive opportunities, which aligns with open innovation supported by distributed control over the data, leading to collaborative development of products and services involving users in decisions.

As Tackara (2016, p.8) states, the design shall “deliver value to people—not deliver people to systems”. Ethics should not be seen only as a legislative obligation but as a guide to the future that society envisions, and design shall take part to collaborate for this sustainability. Therefore, there are many points where a greater understanding of the role of design and possible improvements is needed.

6 Conclusion

This article analysed the factors that influence the socio-ethical dimension of sustainability in S.PSS and DE models. The method applied was a systematic literature review that used six strategies for designing sustainable systems focused on the socio-ethical dimension as criteria. The results brought a diversity of articles in the sense of geographic locations and fields of research, showing the importance of the subject as global and transdisciplinary.

On evidence found, digital technologies have shown advantages in improving workers' conditions, providing safer environments, and offering better and optimised workplaces. In the case of equity, most of the evidence was in meeting the diversity of customer preferences. The co-creation of value through data included customers developing better services and products (Zheng et al., 2019; Li et al., 2020). Another point was that the offer of remote telemonitoring services could favour the inclusion of people with special needs. For social cohesion, the concept of Open Knowledge was presented by the authors intertwined with digital platforms to bring diverse people together and develop online communities (Cangiano et al., 2017; Zheng et al., 2020). The simple act of opening a new communication channel through a function available in a product by Tsunetomo et al. (2022) aided in

better social cohesion between different age parents and their adult children. Also, to enhance local resources, technology can provide better solutions locally (customised), such as the presence of a 3D printer in Beltagui et al. (2020) and Li & Found (2017). Alternatively, improve local service structures as the offer of digital payment is cited by Watanabe et al. (2020). Customisation can reflect on responsible consumption, providing information, choices, or limiting options based on personal data for sustainable behaviour (Li & Found, 2017; Li et al.,2023; Zheng et al., 2019; Zheng et al., 2020; Yang et al., 2021;).

On the negative side, problems were presented regarding inclusion related to access to new technologies and user preparation for them (Jia et al., 2021; Tsunetomo et al., 2022). Points associated with the surveillance of devices equipped with sensors were also raised (Tsunetomo et al., 2022). Zheng et al. (2019) cited the concern about complying with data protection legislation. Cargiano (2017) presented the importance of transparency and more democratic processes. Moreover, finally, Menichinelli (2017) brought the political and socio-ethical influences that technology can have. All the problems could hinder more than one strategy.

Digital technologies can potentially support different design strategies for socio-ethical sustainability in S.PSS and DE. However, due to the disruption its advancement causes in social development (positive or negative), it is necessary to maintain a dialogue and constant development on ethical parameters. In the case of S.PSS and DE design, the six strategies presented touch on ideas within these themes. Nevertheless, due to the significance of contemporary technology and its fast-paced evolution, this article suggests updating the strategies and models to consider crucial issues such as data concentration, violations of privacy and surveillance, and potential barriers to accessing information, products, and services. Raising issues and solutions beyond legal obligations, thus that the professional designer shall be equipped with a solid knowledge base and know-how for conscious and active participation, collaborating with the application of technology for a democratic, fair, and humane future. For future work, it is suggested to deepen the research and the understanding of the designer's role when dealing with the abovementioned ethical issues in the era of disruptive digital technology.

References

Beltagui, A., Kunz, N., & Gold, S. (2020). The role of 3D printing and open design on adoption of socially sustainable supply chain innovation. *INTERNATIONAL JOURNAL OF PRODUCTION ECONOMICS*, *221*. https://doi.org/10.1016/j.ijpe.2019.07.035

Bertoni, A., MacHchhar, R. J., Larsson, T., & Frank, B. (2022). Digital Twins of Operational Scenarios in Mining for Design of Customized Product-Service Systems Solutions. *Procedia CIRP*, *109*, 532–537. https://doi.org/10.1016/j.procir.2022.05.290

Cadwalladr, C., & Graham-Harrison, E. (2018). *Revealed: 50 million Facebook profiles harvested for Cambridge Analytica in major data breach—Cambridge Analytica*. The Guardian. https://www.theguardian.com/news/2018/mar/17/cambridge-analytica-facebook-influence-us-election

Cangiano, S., Romano, Z., & Loglio, M. (2017). The growth of digital social innovation in Europe. An Open Design approach to support innovation for the societal good. *DESIGN JOURNAL*, *20*(1), S3546–S3559. https://doi.org/10.1080/14606925.2017.1352857

Chaves, L. I., Santos, A. dos, Santos, A. S., Mazzieiro, A. T., Cavalcante, A. L. B., Ana Veronica Paz y Mino Pazmino, Andrea de Paula Xavier Vilela, Anna .L.S. Cavalcanti, Carla R. Pasa Gomés, Lima, Flavio Lucio Nunes de, Prado, Gheysa, Murphy, Gisele C. Raulik, Perez, Iana U., Ribeiro, Uliane Pontes, Castillo,

Leonardo, Schmitz, Mariana, Alves, Milena Carneiro, Mourão, Nadja Maria, & Lepre, Priscila Ramalho. (2019). *Design para a Sustentabilidade: Dimensão Social* (1st ed.). Insight.

Chiu, M.-C., Huang, J.-H., Gupta, S., & Akman, G. (2021). Developing a personalised recommendation system in a smart product service system based on unsupervised learning model. *COMPUTERS IN INDUSTRY*, *128*. https://doi.org/10.1016/j.compind.2021.103421

Clark, G., Crul, M.R.M., Diehl, J.C.. 2006. Design for Sustainability: A practical Approach *for developing Economies.* United Nations Environment Programme (UNEP), TU Delft.

Conforto, E. C., & Amaral, D. C. (2011). Roteiro para revisão bibliográfica sistemática: Aplicação no desenvolvimento de produtos e gerenciamento de projetos. *8 Congresso Brasileiro de Gestão de Desenvolvimento de Produto - CBGDP 2011*.

Corbyn, Z. (2023, March 4). Prof Nita Farahany: 'We need a new human right to cognitive liberty'. *The Observer*. https://www.theguardian.com/science/2023/mar/04/prof-nita-farahany-we-need-a-new-human-right-to-cognitive-liberty

Corsini, L., & Moultrie, J. (2021). What Is Design for Social Sustainability? A Systematic Literature Review for Designers of Product-Service Systems. *Sustainability*, *13*(11), Article 11. https://doi.org/10.3390/su13115963

Crawford, K. (2021). *Atlas of AI: Power, politics, and the planetary costs of artificial intelligence*. Yale University Press.

Curley, M., & Salmelin, B. (2013). *Open Innovation 2.O: A New Paradigm*. https://ec.europa.eu/futurium/en/system/files/ged/24-oispgopeninnovation20anewparadigm-whitepaper.pdf

GDPR, 2016/679, 02016R0679-20160504 (2016). https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1532348683434&uri=CELEX%3A02016R0679-20160504

EU. (2023). *Information and communication technologies* [EU regional and urban development]. https://ec.europa.eu/regional_policy/policy/themes/ict_en

GenerativeAI. (2023). *This week alone, more than 200 new AI tools were released.* LinkedIn. https://www.linkedin.com/posts/genai-center_this-week-alone-more-than-200-new-ai-tools-activity-7045374653816610816-sgqN/?trk=public_profile_like_view

Gonzatto, R. F., & Amstel, F. M. C. van. (2022). User oppression in human-computer interaction: A dialectical-existential perspective. *Aslib Journal of Information Management*, *74*(5), 758–781. https://doi.org/10.1108/AJIM-08-2021-0233

Greenwald, G. (2013). *Edward Snowden: The whistleblower behind the NSA surveillance revelations—The NSA files*. The Guardian. https://www.theguardian.com/world/2013/jun/09/edward-snowden-nsa-whistleblower-surveillance

Han, B.-C. (2017). *Psychopolitics: Neoliberalism and new technologies of power* (E. Butler, Trans.). Verso.

Jia, G., Zhang, G., Yuan, X., Gu, X., Liu, H., Fan, Z., & Bu, L. (2021). A synthetical development approach for rehabilitation assistive smart product–service systems: A case study. *Advanced Engineering Informatics*, *48*. https://doi.org/10.1016/j.aei.2021.101310

Johansson, A., Kisch, P., & Mirata, M. (2005). Distributed economies – A new engine for innovation. *Journal of Cleaner Production*, *13*(10), 971–979. https://doi.org/10.1016/j.jclepro.2004.12.015

Kuhlenkötter, B., Wilkens, U., Bender, B., Abramovici, M., Suesse, T., Göbel, J., Herzog, M., Hypki, A., & Lenkenhoff, K. (2017). New Perspectives for Generating Smart PSS Solutions – Life Cycle, Methodologies and Transformation. *Procedia CIRP*, *64*, 217–222. https://doi.org/10.1016/j.procir.2017.03.036

Lanier, J. (2018). *Ten arguments for deleting your social media accounts right now*. The Bodley Head.

Lee, J., & Kao, H.-A. (2014). Dominant Innovation Design for Smart Products-Service Systems (PSS): Strategies and Case Studies. *2014 ANNUAL SRII GLOBAL CONFERENCE (SRII)*, 305–310. https://doi.org/10.1109/SRII.2014.25

Li, A. Q., & Found, P. (2017). Towards sustainability: PSS, digital technology and value co-creation. In T. McAloone, D. Pigosso, N. Mortensen, & Y. Shimomura (Eds.), *9TH CIRP INDUSTRIAL PRODUCT/SERVICE-SYSTEMS (IPSS) CONFERENCE: CIRCULAR PERSPECTIVES ON PRODUCT/SERVICE-SYSTEMS* (Vol. 64, pp. 79–84). Int Acad Prod Engn. https://doi.org/10.1016/j.procir.2017.05.002

Li, A. Q., Lahy, A., Found, P., Kumar, M., & Claes, B. (2023). Developing PSS business ecosystems in the digital era. *Industrial Marketing Management*, *109*, 121–134. https://doi.org/10.1016/j.indmarman.2022.12.017

Li, A. Q., Rich, N., Found, P., Kumar, M., & Brown, S. (2020). Exploring product–service systems in the digital era: A socio-technical systems perspective. *TQM Journal*, *32*(4), 897–913. https://doi.org/10.1108/TQM-11-2019-0272

Menichinelli, M. (2017). A data-driven approach for understanding Open Design. Mapping social interactions in collaborative processes on GitHub. *DESIGN JOURNAL*, *20*(1), S3643–S3658. https://doi.org/10.1080/14606925.2017.1352869

Menichinelli, M. (2018). The Open Design Definition v. 0.5. *Open Design Definition group, GitHub.* github.com/OpenDesign-WorkingGroup/Open-Design-Definition/blob/master/open.design_definition/open.design.definition.md

Mtshalia, T. I., Ramaligelaa, S. M., & Makgatob, M. (2020). *Usage of digital resources in Civil Technology: A case of teaching Tools and Equipment*. African Journal of Science, Technology, Innovation and Development. https://journals.co.za/doi/10.1080/20421338.2019.1609782

Negash, Y. T., & Sarmiento, L. S. C. (2023). Smart product-service systems in the healthcare industry: Intelligent connected products and stakeholder communication drive digital health service adoption. *Heliyon*, *9*(2). https://doi.org/10.1016/j.heliyon.2023.e13137

Negreiro, M., & Madiega, T. (2019). Digital transformation. *Digital Transformation*.

Ogg, C. M. N. G. (2019). *Modelo para estabelecer competências para o futuro do design orientado pelas tecnologias emergentes. 339 f. Tese (Doutorado em Design) – Setor de Artes, Comunicação e Design da Universidade Federal do Paraná* [PhD in Design]. Universidade Federal do Paraná.

Parker, C. (2018). *Artificial intelligence could be our saviour, according to the CEO of Google*. World Economic Forum. www.weforum.org/agenda/2018/01/google-ceo-ai-will-be-bigger-than-electricity-or-fire/

Perez, I. U., & Santos, A. dos. (2017). Distributed Economies Through Open Design and Digital Manufacturing. *MIX Sustentável*, *3*(4), 21–28. https://doi.org/10.29183/2447-3073.MIX2017.v3.n4.21-28

Pirola, F., Boucher, X., Wiesner, S., & Pezzotta, G. (2020). Digital technologies in product-service systems: A literature review and a research agenda. *Computers in Industry*, *123*, 103301. https://doi.org/10.1016/j.compind.2020.103301

Pollina, E., & Mukherjee, S. (2023). *Italy curbs ChatGPT, starts probe over privacy concerns*. Reuters. https://www.reuters.com/technology/italy-data-protection-agency-opens-chatgpt-probe-privacy-concerns-2023-03-31/

Raworth, K. (2012). *A safe and just space for humanity—Can-we-live-within-the-doughnut?* [dataset]. Oxfam. https://doi.org/10.1163/2210-7975_HRD-9824-0069

Sava, J. A. (2022). *Global digital transformation spending 2026*. Statista. https://www.statista.com/statistics/870924/worldwide-digital-transformation-market-size/

Scaglione, T., Fialkowski, V., Lima Silveira, E., & dos Santos, A. (2021). Estado da Arte sobre o uso de Big Data no Design: Perspectiva de Sistemas Produtos + Serviços Sustentáveis. *DAT Journal*, *6*, 2021.

Taylor, P. (2022). *Volume of data/information created, captured, copied, and consumed worldwide from 2010 to 2020, with forecasts from 2021 to 2025 (in zettabytes)*. Statista. https://www.statista.com/statistics/871513/worldwide-data-created/#statisticContainer

Tsunetomo, K., Watanabe, K., & Kishita, Y. (2022). Smart product-service systems design process for socially conscious digitalization. *Journal of Cleaner Production*, *368*. https://doi.org/10.1016/j.jclepro.2022.133172

Tukker, A. , Tischner,U. (2006). *New Business for Old Europe: Product-Service Development, Competitiveness and Sustainability*. Sheffield: Greenleaf Publ.

UE. (2023). *What is personal data?* European Comission. https://commission.europa.eu/law/law-topic/data-protection/reform/what-personal-data_en

Valencia, A., Mugge, R., Schoormans, J. P. L., & Schifferstein, H. N. J. (2015). The Design of Smart Product-Service Systems (PSSs): *Service Systems*, *9*(1).

Vezzoli, C. A., Macrì, L., Takacs, B., & Yang, D. (2022). *System Design for Sustainability in Practice* (1st ed.). Maggioli spa. https://doi.org/10.30448/uni.916.55745

Vezzoli, C., Parra, B. G., & Kohtala, C. (Eds.). (2021). *Designing Sustainability for All: The Design of Sustainable Product-Service Systems Applied to Distributed Economies*. Springer International Publishing. https://doi.org/10.1007/978-3-030-66300-1

Vincent, J. (2017). *Putin says the nation that leads in AI 'will be the ruler of the world'*. The Verge. https://www.theverge.com/2017/9/4/16251226/russia-ai-putin-rule-the-world

Watanabe, K., Okuma, T., & Takenaka, T. (2020). Evolutionary design framework for Smart PSS: Service engineering approach. *ADVANCED ENGINEERING INFORMATICS*, *45*. https://doi.org/10.1016/j.aei.2020.101119

WEF. (2023). *Global Issue: The digital Economy*. Strategic Intelligence. https://intelligence.weforum.org/topics/a1Gb0000001SH21EAG

Yang, X., Wang, R., Tang, C., Luo, L., & Mo, X. (2021). Emotional design for smart product-service system: A case study on smart beds. *JOURNAL OF CLEANER PRODUCTION*, *298*. https://doi.org/10.1016/j.jclepro.2021.126823

Zheng, P., Li, X., Peng, T., Wang, Y., & Zhang, G. (2020). Industrial smart product-service system development for lifecycle sustainability concerns. *IET COLLABORATIVE INTELLIGENT MANUFACTURING*, *2*(4), 197–201. https://doi.org/10.1049/iet-cim.2020.0056

Zheng, P., Lin, T.-J., Chen, C.-H., & Xu, X. (2018). A systematic design approach for service innovation of smart product-service systems | Elsevier Enhanced Reader. *Journal of Cleaner Production*, 657–667. https://doi.org/10.1016/j.jclepro.2018.08.101

Zheng, P., Wang, Z., & Chen, C.-H. (2019). Smart product-service systems: A novel transdisciplinary sociotechnical paradigm. *Advances in Transdisciplinary Engineering*, *10*, 234–241. https://doi.org/10.3233/ATDE190128

Zuboff, S. (2020). *The age of surveillance capitalism: The fight for a human future at the new frontier of power* (First trade paperback edition). PublicAffairs.

About the Authors:

Alessandra C. Canfield Petrecca: Ph.D. Student in Design for Sustainability and a LeNSLab researcher at Politecnico di Milano under the coordination of Professor Carlo Vezzoli. Her research crosses the subjects of Design for Sustainability, Digital Technology, Sustainable Product-Service Systems, Distributed Economy, and Socio-Ethics.

Carlo Vezzoli: Full Professor of Design at the Politecnico di Milano. Founder of the Learning Network on Sustainability (LeNS), with around 150 Universities worldwide aiming to spread Design for Sustainability. Awarded a PhD Honoris Causa by the Federal University of Parana.