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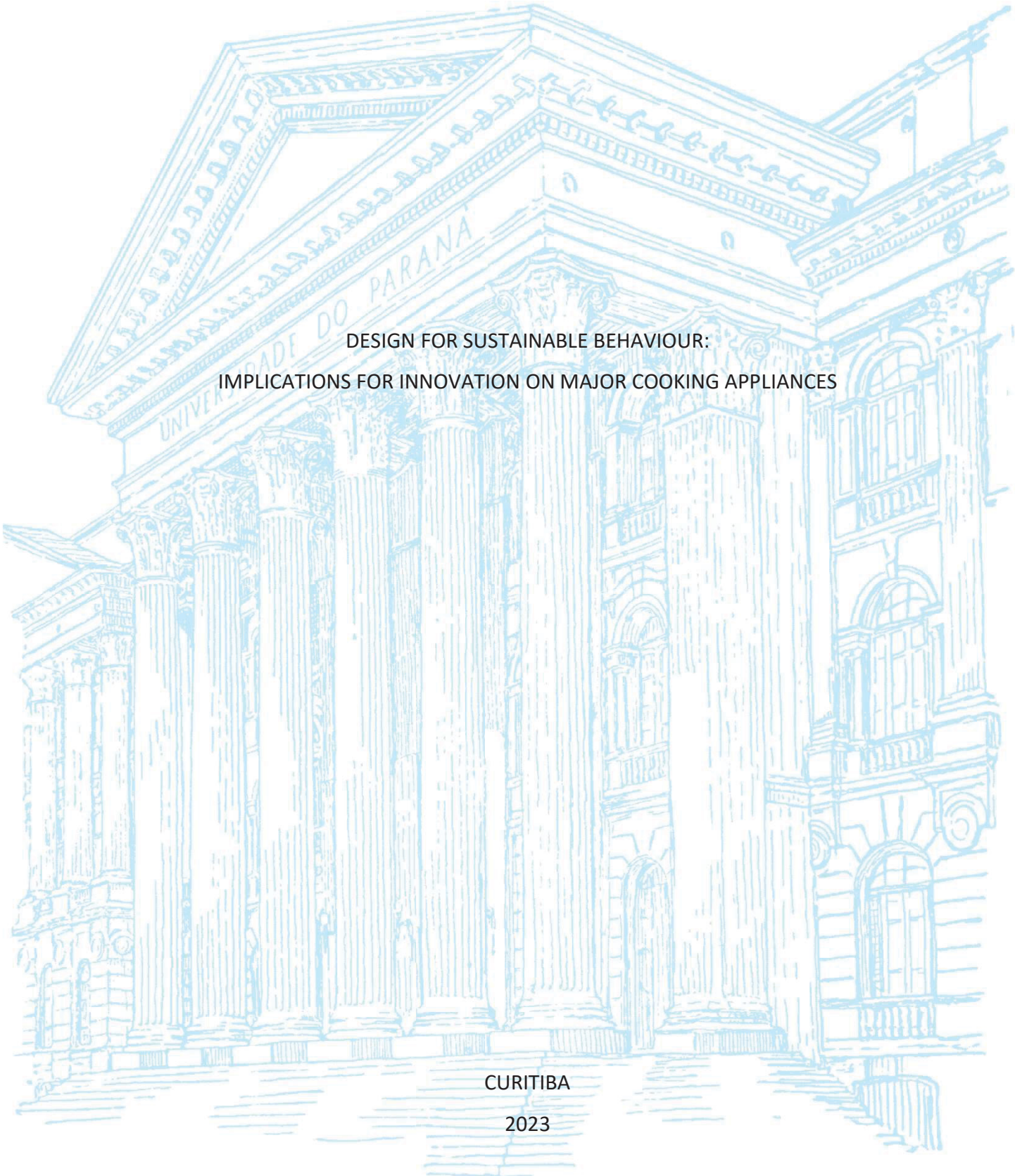

DESIGN FOR SUSTAINABLE BEHAVIOUR:
IMPLICATIONS FOR INNOVATION ON MAJOR COOKING APPLIANCES

CURITIBA

2023

KARLA MAYKE CÍRICO SCHERER SCHLICHTING

DESIGN FOR SUSTAINABLE BEHAVIOUR:
IMPLICATIONS FOR INNOVATION ON MAJOR COOKING APPLIANCES

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Orientador: Prof. Dr. Aguinaldo dos Santos
Coorientadora: Prof.ª Dr.ª Debra Lilley

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Os membros da Banca Examinadora designada pelo Colegiado do Programa de Pós-Graduação DESIGN da Universidade Federal do Paraná foram convocados para realizar a arguição da dissertação de Mestrado de **KARLA MAYKE CÍRICO SCHERER** intitulada: **Design for Sustainable Behavior: Implications for Innovation on Major Cooking Appliances**, sob orientação do Prof. Dr. AGUINALDO DOS SANTOS, que após terem inquirido a aluna e realizada a avaliação do trabalho, são de parecer pela sua APROVAÇÃO no rito de defesa.

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Dedicated to my child who will be forever in my heart.

(*In memoriam*)

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The most important thanks I reserve for my mother and my husband. With your immense love and patience, you have always supported and encouraged me to follow the path I believe in. I couldn't have gotten so far without you. Another special thanks to my pets, Dexter and Axl, who made the path more pleasant with their love.

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To all the women who have preceded me and paved the path of science that I’ve walked so far, my gratitude. I am because you are.

“Behavioural change is more important than individual product choices. They both have a role to play.”

JOHN ELKINGTON

RESUMO

As decisões tomadas na atividade de cozinhar impactam as práticas sociais, econômicas e ambientais ao longo da cadeia de valor do sistema de alimentação sustentável. Na contemporaneidade, a cocção tem incorporado novos valores e práticas, além de atender às necessidades fisiológicas. Concomitante à busca por dietas mais saudáveis, o hábito de cozinhar proporciona experiências que fortalecem as relações interpessoais e a construção de identidades culturais. No entanto, hábitos insustentáveis na atividade de cozinhar podem afetar recursos hídricos, consumo de energia, desperdício de alimentos e as mudanças climáticas, através de emissões de gases de efeito estufa. Neste cenário, o Design para o Comportamento Sustentável visa apoiar soluções orientadas a influenciar comportamentos, durante a fase de uso dos produtos, em prol de decisões mais sustentáveis. Estratégias de Design para o Comportamento Sustentável podem ser aplicadas por profissionais de design no intuito de informar ou conduzir o usuário a comportamentos mais sustentáveis, ou ainda, garantir que a mudança ocorra de forma automática e imperativa. Este estudo apresenta parâmetros guiados por estratégias de Design para o Comportamento Sustentável a fim de assistir designers no âmbito do desenvolvimento de eletrodomésticos, visando uma cocção sustentável. O método de pesquisa selecionado para a condução deste estudo foi o Design Science Research que consistiu em quatro etapas caracterizadas pela compreensão do problema, geração de ideias, desenvolvimento e avaliação. A revisão bibliográfica sistemática e Survey foram utilizados na etapa inicial relativa à compreensão do problema e workshops colaborativos foram adotados nas etapas de geração de ideias e desenvolvimento. A etapa de desenvolvimento envolveu a colaboração de profissionais da Electrolux, fabricante multinacional de eletrodomésticos e parceira neste estudo, que contou também com a contribuição da Universidade de Loughborough, na Inglaterra. Os resultados apontam para a necessidade de conduzir designers a adotarem estratégias de Design para o Comportamento Sustentável adequadas às tomadas de decisão desejadas no hábito de cozinhar, dentro da prática do design.

Palavras-Chave: Design; Sustentabilidade; Design para o Comportamento Sustentável - DCS; Cocção Sustentável; Eletrodomésticos.

ABSTRACT

Decisions made in the cooking activity impact social, economic, and environmental practices along the value chain of the sustainable food system. In contemporary times, cooking has incorporated new values and practices in addition to meeting physiological needs. Along with the search for healthier diets, cooking provides experiences that strengthen interpersonal relationships and develop cultural identities. However, unsustainable cooking habits can affect water resources, energy consumption, food waste, and climate change through greenhouse gas emissions. In this scenario, Design for Sustainable Behavior aims to support solutions oriented to influence behavior during the use phase of products to achieve more sustainable decisions. Design professionals can apply Design for Sustainable Behavior strategies to inform or guide the user towards more sustainable behaviors or to ensure that change occurs automatically and imperatively. This study presents parameters guided by Design for Sustainable Behavior strategies to assist designers in developing home appliances for sustainable cooking. The research method selected to conduct this study was Design Science Research, which consisted of four stages: problem understanding, idea generation, development, and evaluation. The systematic literature review and the Survey method were applied in the initial stage concerning the understanding of the problem, and collaborative workshops were adopted in the stages of idea generation and development. The development stage involved professionals from Electrolux, a multinational manufacturer of household appliances and a partner in this study, which also included a contribution from Loughborough University, UK. The results point to the need for guidance for designers to adopt Design for Sustainable Behavior strategies appropriate to the desired decision-making in the cooking habit within their practice.

Keywords: Design; Sustainability; Design for Sustainable Behaviour - DfSB; Sustainable Cooking; Household Appliances.

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LIST OF FIGURES

FIGURE 1.1 - Timeline of research on Design for Sustainable Behaviour at NDS/UFPR 20
FIGURE 1.2 - Sustainable Developed Goals associated with this study 27
FIGURE 1.3 - Delimitation of the study areas and main objective 28
FIGURE 1.4 - Research Method Overview 30
FIGURE 2.1 - Theoretical position of Design for Sustainable Behaviour 36
FIGURE 2.2 - The Design for Sustainability Evolutionary Framework 39
FIGURE 2.3 - User-centred Design context 41
FIGURE 2.4 - Categorization of approaches in relation to behavioural theories 43
FIGURE 2.5 - Loughborough University DfSB Model (2011) 44
FIGURE 2.6 - Average of meals home-cooked per week in 2020 47
FIGURE 2.7 - Health and social determinants and outcomes of home cooking 48
FIGURE 2.8 - Percentage of households in Brazil per type of fuel used in food preparation 50
FIGURE 2.9 - Brazilian biomes 54
FIGURE 2.10 - Gas Stove by Norman Bel Guedes from 1932 61
FIGURE 2.11 Food System Wheel 63
FIGURE 2.12 - Cooking process steps. 64
FIGURE 2.13 - Energy consumption across Food System 66
FIGURE 2.14 - Global energy consumption by sector in the year 2021 66
FIGURE 2.15 - Brazilian energy consumption by sector in the year 2021 67
FIGURE 2.16 - Paygas Case by Venture Catalyst Program, 2021. 74
FIGURE 2.17 - Lilley's axis (2007) 75
FIGURE 2.18 - Strategies to inform the change 76
FIGURE 2.19 - Tramontina induction cooktop 76
FIGURE 2.20 - Smeg oven 77
FIGURE 2.21 - SECO food dehydrator 78
FIGURE 2.22 - Strategies to guide the change 78
FIGURE 2.23 - Smeg induction cooktop 79
FIGURE 2.24 - Strategies to ensure the change 80
FIGURE 2.25 - Winia microwave 80
FIGURE 2.26 - Miele induction cooktop 81
FIGURE 3.1 - Research Strategy Overview 88
FIGURE 3.2 – Persona 01 93
FIGURE 3.3 – Persona 02 93
FIGURE 3.4 – Persona 03 94
FIGURE 3.5 – DfSB Strategy cards 95
FIGURE 3.6 – Cooking Habit cards 97

FIGURE 3.7 – Work board 98
FIGURE 3.8 – Double Diamond Process 99
FIGURE 4.1 – Global cooking appliance manufacturers 103
FIGURE 4.2 – Workshop 1 | DfSB presentation at Electrolux, Curitiba, Brazil 108
FIGURE 4.3 – Workshop 1 | DfSB Gym 109
FIGURE 4.4 – Persona | Mariana 109
FIGURE 4.5 – DfSB Strategy cards 110
FIGURE 4.6 – Round 1 | The most voted propositions 110
FIGURE 4.7 – Persona | Ana 112
FIGURE 4.8 – Round 2 | The most voted propositions 112
FIGURE 4.9 – Persona | Roberta 114
FIGURE 4.10 – Round 3 | The most voted propositions 114
FIGURE 4.11 – Workshop 2 | Ideation process 117
FIGURE 4.12 – Cooking habit cards 118
FIGURE 4.13 – Work board 119
FIGURE 4.14 – Resulted board of ideas resulted from Workshop 2 120
FIGURE 4.15 – Brazilian energy efficiency label 121
FIGURE 4.16 – Final version of guidelines 137

LIST OF GRAPHICS

GRAPHIC 1.1 – Research based on the Loughborough model (Bhamra et al., 2011) over the last 10 years 29
GRAPHIC 2.1 - Monthly average expenditure on food in Brazil per family's income (%)..... 51
GRAPHIC 3.1 - Doctoral theses and master's dissertations in Design published in Brazil using the keywords Design, Cooking and Sustainability (from 2011 to 2021)..... 85
GRAPHIC 4.1 - A-Guidelines' categories distribution..... 133
GRAPHIC 4.2 - B-Guidelines' categories distribution..... 134
GRAPHIC 4.3 - C-Guidelines' categories distribution..... 134
GRAPHIC 4.4 - D-Guidelines' categories distribution 135
GRAPHIC 4.5 - Preliminary guidelines and their distribution in the categories of design process 135

LIST OF TABLES

TABLE 4.1 - Global product benchmarking | stoves & cooktops)..... 103
TABLE 4.2 – Guidelines' version 1.0 124
TABLE 4.3 – Profile of Experts in Cooking Appliance Design 129

LIST OF ACRONYMS AND ABBREVIATIONS

ABNT	Brazilian Association of Technical Standards
BDTD	Brazilian Digital Library of Theses and Dissertations
BRL	Brazilian Real, the official currency of Brazil
CCA	Clean Cooking Appliance
COVID-19	Coronavirus Disease 2019
DfBC	Design for Behavioural Change
DfSB	Design for Sustainable Behaviour
DIEESE	Inter-union Department of Statistics and Socio-economic Studies
DSR	Design Science Research
ELETROS	Brazilian Association of Electrical and Electronic Products Manufacturers
EPE	Energy Research Office
FAO	Food and Agriculture Organization of the United Nations
FDA	The United States Food and Drug Administration
FINEP	Funder of Studies and Projects
GHG	Greenhouse Gas
IBGE	Brazilian Institute of Geography and Statistics
IEA	International Energy Agency
INMETRO	National Institute of Metrology, Quality and Technology
IoT	Internet of Things
IPEA	Institute for Applied Economic Research
LPG	Liquefied Petroleum Gas
N-SLR	Non-Systematic Literature Review
NBR	Brazilian Standard
NDS	Design & Sustainability Research Center
OED	Oxford English Dictionary
PPGDesign	Post-Graduate Programme
S.PSS	Sustainable Product-Service System
SDGs	Sustainable Development Goals
SLR	Systematic Literature Review
UFPR	Federal University of Paraná

UK	United Kingdom
UN	United Nations
UNEP	United Nations Environment Program
UX	User Experience
WELS	Water Efficiency Labelling and Standards
WHO	World Health Organization

CONTENTS

1 INTRODUCTION 19

1.1 CONTEXT 19

1.2 RESEARCH PROBLEM 21

1.3 MAIN OBJECTIVES 23

1.4 ASSUMPTIONS 24

1.5 JUSTIFICATIVE 25

1.6 RESEARCH SCOPE 28

1.7 METHOD OVERVIEW 30

1.8 DISSERTATION STRUCTURE 31

2 DESIGN FOR SUSTAINABLE COOKING 33

2.1 DESIGN FOR SUSTAINABLE BEHAVIOUR 33

2.1.1 The Role of Design in Fostering Sustainable Behaviour 33

2.1.2 Defining "Design for Sustainable Behaviour" 36

2.1.3 Brief Historical Context 38

2.1.4 Theories and Strategies on Design for Sustainable Behaviour 42

2.1.5 Limitations of "Design for Sustainable Behaviour" 45

2.2 THE COOKING HABIT 46

2.2.1 Definition of Cooking 46

2.2.2 Factors Affecting Home Cooking Habits 47

2.2.3 Brazilian Cooking Habits 50

2.3 COOKING METHODS 57

2.4 COOKING APPLIANCES 59

2.5 THE SUSTAINABLE DIMENSIONS OF SUSTAINABLE COOKING 63

2.5.1 The Impacts of Cooking on the Environmental Dimension 65

2.5.2 Main Impacts of Cooking on the Social Dimension 68

2.5.3 The Impacts for Economical Dimension 72

2.6 DESIGN FOR SUSTAINABLE BEHAVIOUR APPLIED TO COOKING PRODUCTS 75

2.6.1 General Strategies 75

2.7 DISCUSSION 81

3 RESEARCH METHOD 84

3.1 CHARACTERIZING THE RESEARCH PROBLEM 84

3.2 SELECTION OF THE RESEARCH METHOD 86

3.3 RESEARCH STRATEGY OVERVIEW 88

3.3.1 Phase 1 | Literature Review 88

3.3.2 Phase 2 | Survey 90

3.3.3 Phase 3 | Ideation 91

3.3.3.1 Workshop 1 91

3.3.3.1.1 Characterizing Personas 91
3.3.3.1.2 DfSB strategy cards 94
3.3.3.2 Workshop 2 96
3.3.4 Phase 4 | Development 99
3.3.5 Phase 5 | Evaluation 99
3.3.6 Phase 6 | Reflections 100
4 RESULTS & ANALYSIS 101
4.1 PHASE 1 | LITERATURE REVIEW 101
4.2 PHASE 2 | PROBLEM AWARENESS 101
4.2.1 Survey 101
4.3 PHASE 3 | IDEATION 106
4.3.1 Workshop 1 106
4.3.1.1 Generating DfSB guidelines through product ideation 106
4.3.2 Workshop 2 115
4.4 PHASE 4 | DEVELOPMENT 121
4.5 PHASE 5 | EVALUATION 129
4.6 PHASE 6 | REFLECTIONS 132
4.6.1 Contributions to the household appliance industry 132
4.6.2 Skills required from the designer for the practical application of the guidelines 133
4.6.3 Contributions toward expanding generalist theory of Design for Sustainable Behaviour 134
4.6.4 Final version of guidelines 134
5 CONCLUSION 142
5.1 FINAL CONSIDERATIONS 142
5.2 RESEARCH METHOD CONSIDERATIONS 143
5.3 SUGGESTIONS FOR FUTURE STUDIES 144
REFERENCES 145
APPENDIX I – SYSTEMATIC LITERATURE REVIEW PROTOCOL 160
APPENDIX II – A-GUIDELINES 161
APPENDIX III – SURVEY PROTOCOL 164
APPENDIX IV – B-GUIDELINES 166
APPENDIX V – WORKSHOP 1 PROTOCOL 167
APPENDIX VI – C-GUIDELINES 169
APPENDIX VII – WORKSHOP 2 PROTOCOL 171
APPENDIX VIII – D-GUIDELINES 173
APPENDIX IX – CROSS-FINDINGS 175
APPENDIX X – EVALUATION OF THE GUIDELINES VERSION 1.0 181
ANNEX I – CONSENT FORM 182

1 INTRODUCTION

This chapter initially describes the context setting of this MSc dissertation, followed by a presentation of the research problem, the main objectives and associated assumptions. It also includes other introductory elements such as justification, research scope, research method overview, and a general overview of the dissertation's structure.

1.1 CONTEXT

This research was carried out within Design & Sustainability Research Center (NDS/UFPR), which is a research group within the Design Post-Graduate Programme at the Federal University of Paraná (UFPR), Brazil. Its implementation at UFPR occurred via a project funded by the FINEP (Brazilian Innovation Agency) 's Verde Amarelo Fund in 2003, in which Electrolux, also a partner on the present research, was one of the signatories of the application.

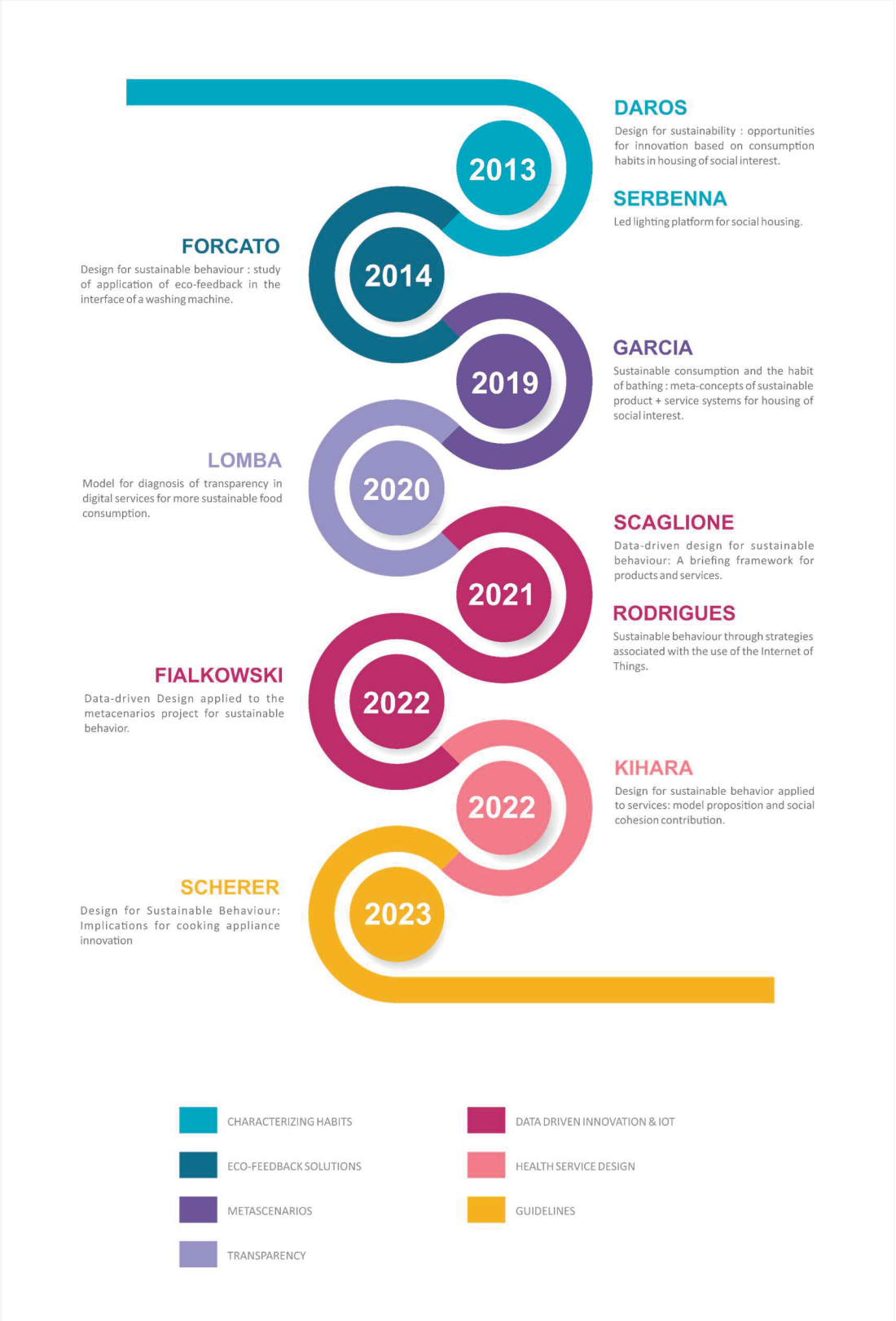
Since its foundation, this research group has explored different concepts, principles, heuristics, methods and tools to promote more sustainable consumption and production patterns, including design for lifecycle, product-service system design, design for the base of the pyramid, and design for social innovation.

Following an evolutionary path, around 2010 it began to recognize the importance of changing consumer behaviour and habits. The efforts to develop competencies on Design for Sustainable Behaviour (DfSB) has led to collaboration with several universities and, in particular, with Loughborough University (United Kingdom).

Since then, a continuous stream of studies from the NDS/UFPR have aimed to find solutions for products, services and systems to increase their sustainability by means of changing consumer behaviour. The research outcomes of these studies include characterization of consumer habits (DAROS, 2013; SERBENA, 2013); design of eco-feedback solutions (FORCATO, 2014); development of meta-scenarios for more sustainable behaviour (GARCIA, 2019); a model for diagnosis of transparency in digital service contemplating behavioural change (NICASTRO, 2020); the use of Big data in DfSB (SCAGLIONE, 2021; FIALKOWSKI, 2022); the application of DfSB in Service Design (KIHARA, 2022) and, more

recently, the object of the present research, dealing with the implications of DfSB in household cooking appliances, as shown in Figure 1.1.

FIGURE 1.1 - Timeline of research on Design for Sustainable Behaviour at NDS/UFPR



SOURCE: Author (2023)

These research developments present synergies with other research from PPGDesign / UFPR in progress at the time of this work, highlighting the ongoing PhD thesis developed by Marcella Lomba, that focuses on the implementation of transparency for digital services towards sustainable behaviors.

1.2 RESEARCH PROBLEM

Over recent decades, Sustainability has been broadly explored by Design research, from a narrow material perspective to broader socio-technical systems or even a biocentric perspective (CESCHIN, & GAZIULUSOY, 2020). The challenges presented by sustainability have increasingly been understood as wicked problems since the solutions are not true-or-false, but better or worse; there is no immediate and no ultimate test of a solution; every solution is a "one-shot operation" and not always possible to learn by trial and error; every problem is essentially unique (RITTEL & WEBBER, 1973). As argued by Tischner & Beste (2017) the complexity of sustainability entails a significant challenge for society.

Design has an intrinsic potential contribution to change consumer behaviours associated with products, services and systems. Decisions made in the design process while a product or service is being developed affect 70% of the impacts generated by the final solution (FABRYCKY, 1987; BHAMRA & LOFTHOUSE, 2007; ELIAS, 2011), requiring an ethical and responsible attitude from this creative professional.

Understanding the impacts caused by user behaviour and the ways in which design can influence new behaviours constitute the purpose of the Design for Sustainable Behaviour, a research topic within the broad themes of Design for Sustainability that emerged in the second half of the 2000s (CESCHIN & GAZIOULUZOI, 2020). It is a field of research that explores how design can influence user behaviour to reduce the negative impacts of social or environmental use (BHAMRA, LILLEY & TANG, 2011).

Whilst the theory and methods associated with Design for Sustainable Behaviour has rapidly evolved in the past two decades there is now a demand for translating it into the specific demands of industrial sectors, such as the white goods industry. The present research focuses on the use of DfSB on household appliances, particularly to cooking appliances development.

In Brazil, the home appliance industry approaches Design for Sustainability mainly through strategies related to Ecodesign, which are usually applied from a technical perspective, and do not sufficiently consider aspects such as the influence that user behaviour can exert on the overall impact of the product (CESCHIN & GAZIULUSOY, 2020; BHAMRA, LILLEY & TANG, 2011).

However, the efforts to adopt more sustainable materials, implement more eco-efficient manufacturing processes or life cycle design of products, can be overshadowed by the negative impacts of consumer behaviour. Indeed, consumer habits associated with food preparation and consumption, for instance, significantly impact sustainable food through the excessive use of water and energy sources, excessive generation of food waste (MARKOVIC, 2018), disregard for seasonal choices when selecting the ingredients, inappropriate discharge of organic waste, excessive use of packaging (GREEN & YOUNG, 2000), among other issues.

To achieve a more sustainable food system it is essential to consider steps involved from the food production to the table, focusing on food security, improved nutrition, and promoting more sustainable agriculture. Among these steps is the cooking process that involves cleaning, separating, cooking, refrigerating and freezing food (FDA, 2017), to enhance the nutritional value, facilitate digestion, increase palatability and prevent microbial growth (FRANCO, 2017).

The practice of cooking denotes a prehistoric activity and its subject is widely investigated in the field of gastronomy and nutrition. However, there is limited intersection with Design for Sustainable Behaviour studies. Some studies suggesting the use of Design for Sustainable Behaviour strategies in cooking appliances do not characterise what defines sustainable cooking and ignore the cultural aspects that influence the user's decision making in the cooking activity.

According to Frankowska et al. (2020), the contributions of cooking to environmental and socioeconomic impacts are rarely evaluated due to the scarcity of data. Most sustainable food-oriented research measures the negative effects caused by food until it is sold, disregarding the consumption that involves food preparation. Reduce negative impacts on consumption for sustainability implies cooking food at home using sustainable methods (FRANKOWSKA et al., 2020); making use of shared kitchens for accessing highly efficient equipment and collectively managing the purchase of ingredients and waste management; adopting technologies (digital or analogic) that enables eco-efficient cooking habits; buying

meals produced locally and with local ingredients, with re-usable containers, when delivery is unavoidable, among other approaches (GREEN & YOUNG, 2000).

Whether in the restricted scope of isolated artifacts or, more broadly, throughout the value chain, it is recognized that Design, and the designer, possess skills and knowledge capable of redirecting behaviors towards more sustainable patterns (HARTMANN & SANTOS, 2022). In this sense, influencing new cooking habits can significantly contribute to more sustainable consumption and production (UN DESA, 2016), commitments within the UN's Agenda 2030.

Relevant contributions to energy efficiency can be observed in the use phase of cooking products such as cookers, hobs, ovens and microwaves. However, increasing the effectiveness of this contribution requires consideration of systemic demands to effectively achieve sustainable cooking (e.g., instrumentalize the adoption of seasonal recipes, including the adoption of local inputs; enable the integration of vulnerable people in the value chain associated with cooking). These contributions include considering the potential influences that products and services can have in changing habits and consumers behaviours in cooking and may influence lifestyles, attitudes, and opinions relevant to sustainability. This last aspect is the focus of this dissertation, placing designers as an effective agent of change by inducing more sustainable behaviors.

Faced with this research problem, the following question was raised: How to guide innovation on major cooking appliances during the design process towards sustainable behaviour?

1.3 MAIN OBJECTIVES

Intending to answer the question raised in the previous topic, the main objective of this dissertation is to propose Design for Sustainable Behavior guidelines to assist designers in developing home cooking appliances.

The secondary objectives conducted to achieve the established goal are detailed below:

A) To characterize the concept of Sustainable Cooking, its environmental impacts on the Brazilian context and the general habits that are associated with more sustainable habits on this activity;

B) To explore the implications of DfSB in terms of product innovation in a real-world industrial context;

C) To identify the key competencies required by design professionals interested in applying DfSB on household appliances.

1.4 ASSUMPTIONS

According to the objectives presented, this research is supported by the following assumptions:

a) Guidelines based on the strategies of Design for Sustainable Behaviour can support designers' decision-making in product development, aiming to influence sustainable behaviours in the cooking habit, resulting in faster and more accurate propositions. This assumption is based on the notion that DfSB needs to adopt a language more accessible to professionals, as already pointed by Niedderer et al. (2014) in their DfSB review.

b) Designers, understood as agents influencing behaviors in the cooking activity, can significantly contribute to the achievement of the Sustainable Development Goals (UNEP, 2015), particularly those associated with sustainable consumption and production of food.

c) The characterization of Sustainable Cooking from the perspective of design allows professionals - by understanding the benefits for the users and the environment in which they are inserted, as well as the most sustainable methods that promote less impact - to develop more accurate solutions directed to the effective needs of users in respect to achieving sustainable cooking. This assumption is based on a scenario where the designer occupies a position of an educational agent, informing and guiding the user through products, services and systems, towards more sustainable decision-making.

d) The maturity levels of Sustainable Design among designers operating in the household appliance manufacturing sector are diverse, yet largely focus on the environmental dimension of sustainability. Hence, the assumption here is that Design for Sustainable Behaviour will be understood by the participants in the field research as novel knowledge, requiring new and inter/multidisciplinary competencies.

1.5 JUSTIFICATIVE

Sustainable cooking comprises part of the consumption stage of the Sustainable Food System, one of the commitments to achieve the goals of the 2030 UN Agenda (UNEP, 2015) for sustainable development. It aims to ensure food and nutrition security without compromising future generations' economic, social, and environmental resources (FAO, 2014).

Although global food production is capable of supplying the needs of the entire planet's population (FAO, 2014), current estimates show that nearly 690 million people are hungry, or 8.9 percent of the world's population - an increase of 10 million people in one year and nearly 60 million in five years (FAO, FIDA, OMS, PMA & UNICEF, 2021).

Achieving the goal of reducing hunger already presented a challenge that was unlikely to be met by 2030, given that in 2019 more than 2 billion people worldwide needed more regular access to safe, nutritious, and sufficient food (UN, 2022). However, the pandemic of COVID-19 has considerably worsened this scenario. The increase in food insecurity in 2020 was equivalent to the previous five years, and the most severe level reached 12% of the world's population (FAO, 2021).

The severe impacts of the pandemic and the political-economic crises faced by Brazil from 2019 to 2022 resulted in more than 61 million Brazilians living in food insecurity (FAO, 2022). In this context, the country faces a setback similar to the 1990s, which is why the United Nations placed Brazil on the hunger map again in 2022 (REDE PENSSAN, 2022).

In this sense, it is essential to note that the impacts caused by unsustainable cooking behaviors can amplify food insecurity and make it impossible to achieve SDG 2, related to the global fight against hunger (UN DESA, 2016). The significant impacts of cooking food are related to fuel sources, appliance efficiency, and consumer behavior during usage (HAGER & MORAWICKI, 2013).

Globally, buildings are responsible for about 40% of the energy consumed and 30% of the greenhouse gas emissions (KAMMEN & SUNTER, 2016). From this point, a significant part of energy consumption, approximately 20%, occurs in the cooking process (HAGER & MORAWICKI, 2013). Even as a country predominantly using LPG gas to prepare household meals (IBGE, 2018), Brazil accounts for over 52% of residential energy consumption in cooking practices (IEA, 2022).

Besides being a relevant destination for water consumption, cooking activity represents (includes the cleaning of utensils) about 13% of all residential water consumption (WELS, 2018).

Furthermore, consumption decisions associated with cooking - such as opting for seasonal, organic, locally produced foods and valuing local knowledge and culture - results in a significantly amplified potential impact on sustainability's social, environmental, and economic dimensions. According to ANDRÉ (2013), consuming food from local producers benefits local economic development, respects production pressures, and uses less environmentally aggressive techniques. Greater proximity between producers and consumers through the commercialization of food at local municipal markets contributes to the strengthening of sustainable communities (ANDRÉ, 2013);

Considering the valorization of local knowledge and culture in food cooking, proposing global solutions with minimal impact on cultural habits is a great challenge. Brazil, with its continental dimensions, presents regions with unique particularities due to the differences in climate, relief, soil type, vegetation, and people living in the same region (BRASIL, 2013). Cultural habits directly affect decisions on food preparation methods and times. Learning about sustainable methods and cooking times for food is crucial for reducing these impacts. Minimizing cooking times and appliance use can reduce GHG emissions by up to 86%. (FRANKOWSKA et al., 2020).

One of the sustainable cooking practices includes home cooking, which can assist in reducing the risk of obesity (KRAMER et al., 2012) and adopting a healthy food consumption pattern (SIMMONS & CHAPMAN, 2012). However, educating the consumer about healthier habits is important since people with lower incomes usually buy the cheapest foods, which are rich in fats and carbohydrates (MILLS et al., 2017). Governmental and non-Governmental organizations worldwide promote home cooking to combat obesity and poor-quality diets (GATLEY et al., 2014). In Brazil, the Food Guide for the Brazilian Population presents principles and recommendations for an adequate and healthy diet, configuring itself as a support tool for food and nutrition education actions (BRASIL, 2014).

However, there is a lack of initiatives connecting these actions directed at food consumption behaviour with industrial practices in the household appliance sector. In the

present scenario, current regulations and legislation mainly deal with the disposal of products and waste, as in the case of law no. 12,305 of August 2010 that establishes the Brazilian solid waste management policy and decree no. 10,240 of February 2020, which regulates the mandatory reverse logistics system in the country. Other requirements for the appliance sector are found in regulations dealing with user safety during product usage (ABNT NBR 13723-1; ABNT NM 60335-1), which do not consider the impact of user behaviour. In addition to this lack, in the Brazilian context, there are no guidelines based on sustainable behaviour that can support professionals in the design of cooking products.

The translation of the principles and recommendations of Design for Sustainable Behaviour and Sustainable Cooking combined with industrial know-how can assist designers in developing more assertive products to influence behaviours that, in the long term, can bring significant cultural changes toward sustainability.

This research works on the field that converges to achieve four of the SDGs, as illustrated in figure 1.2.

FIGURE 1.2: Sustainable Developed Goals associated with this study

SOURCE: The author (2022), based on the United Nations SDGs (2015).

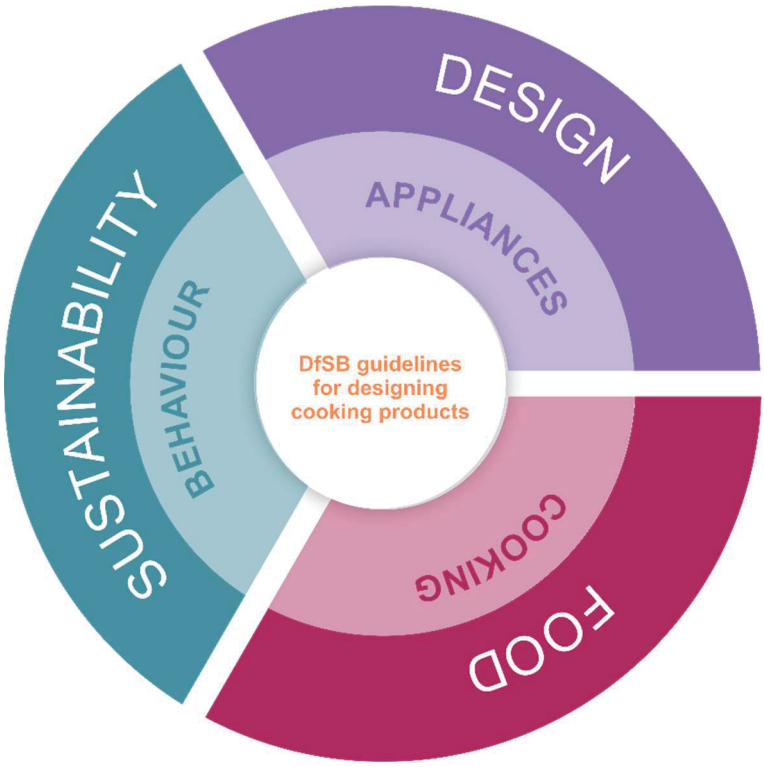
The cooking activity under this research perspective is related to the 2nd and the 3rd goals, which deal with sustainable food and health/wellness, respectively. The responsibility of designers, companies, and users toward sustainable behavioural changes in daily routine

food preparation is strictly related to the 12th goal, dealing with responsible consumption and production. Finally, the international collaboration between the Federal University of Paraná (Brazil), Loughborough University (UK), and the Electrolux household appliance manufacturer, contribute to the expansion of goal 17, which aims to build partnerships for sustainable development.

1.6 RESEARCH SCOPE

This research is delimited by the intersection of three study fields: Design, Sustainability, and Food. Within the area of Design, its scope is framed on products. Under the lens of sustainability, the analysis takes place within the behavioural perspective. Finally, this investigation highlights the cooking practice, a part of the food value chain, that occurs while preparing food. The cross-linking of the mentioned sub-themes describes the scope of this research, as illustrated on Figure 1.3.

FIGURE 1.3 - Delimitation of the study areas and main objective

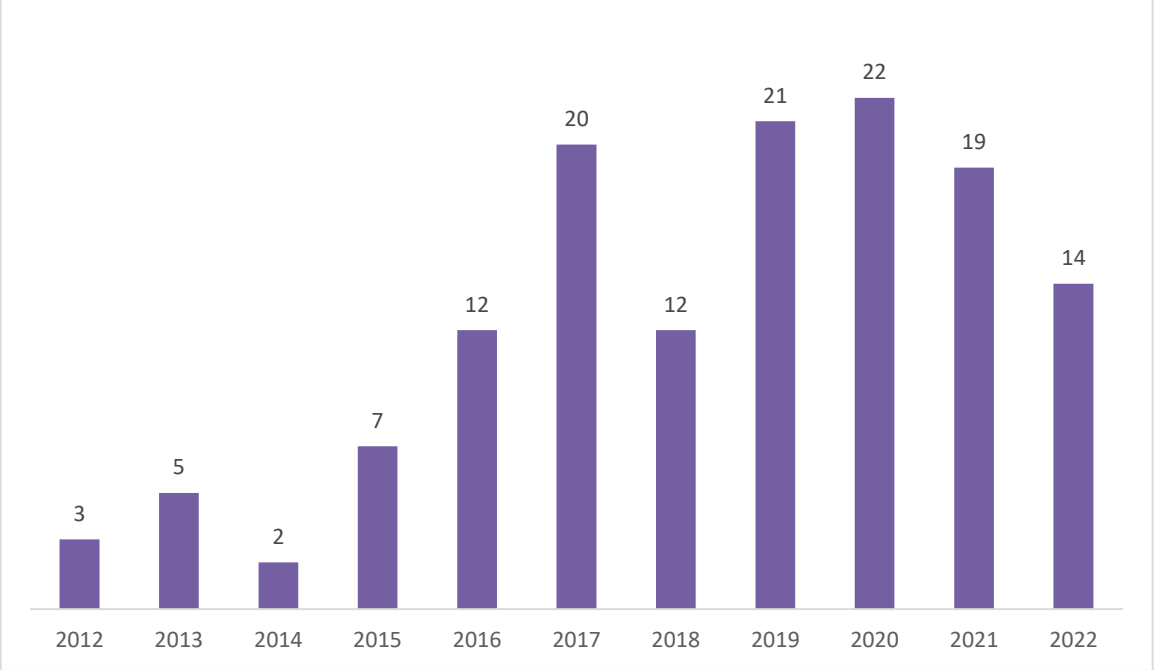


SOURCE: Author (2022)

In order to guide the definition of the DfSB strategy, the model proposed by Bhamra, Lilley, and Tang (2011) was employed as a theoretical framework, with its seven DfSB

strategies. The reason for choosing this model is based on the fact that the model presents a good diversity of proposals that have already been extensively tested and discussed by other authors in this field over the last decade. According to the Scopus database, approximately 137 publications from 2013 to 2023 explored the application and repercussions of Loughborough's model (BHAMRA et al., 2011), as reported in graphic 1.1.

GRAPHIC 1.1 – Research based on the Loughborough model (Bhamra et al., 2011) over the last 10 years



SOURCE: Scopus (2023)

Nevertheless, the research scope is limited to the elaboration of guidelines, on a tactical-operational level, to design major appliances oriented to the practice of sustainable cooking. The term guideline means the outlining of a plan, a path, a prospectus, or a program. Guidelines are considered information or instructions intended to advise people on how something should be done or what something should be (OED, 2023). Guidelines are defined here as technical instructions driven by the principles and heuristics of Design for Sustainable Behavior in cooking practice. Due to the limitations of the level and duration of the Master's programme, other stages of the design process that could benefit from the use of these guidelines are not addressed in this study.

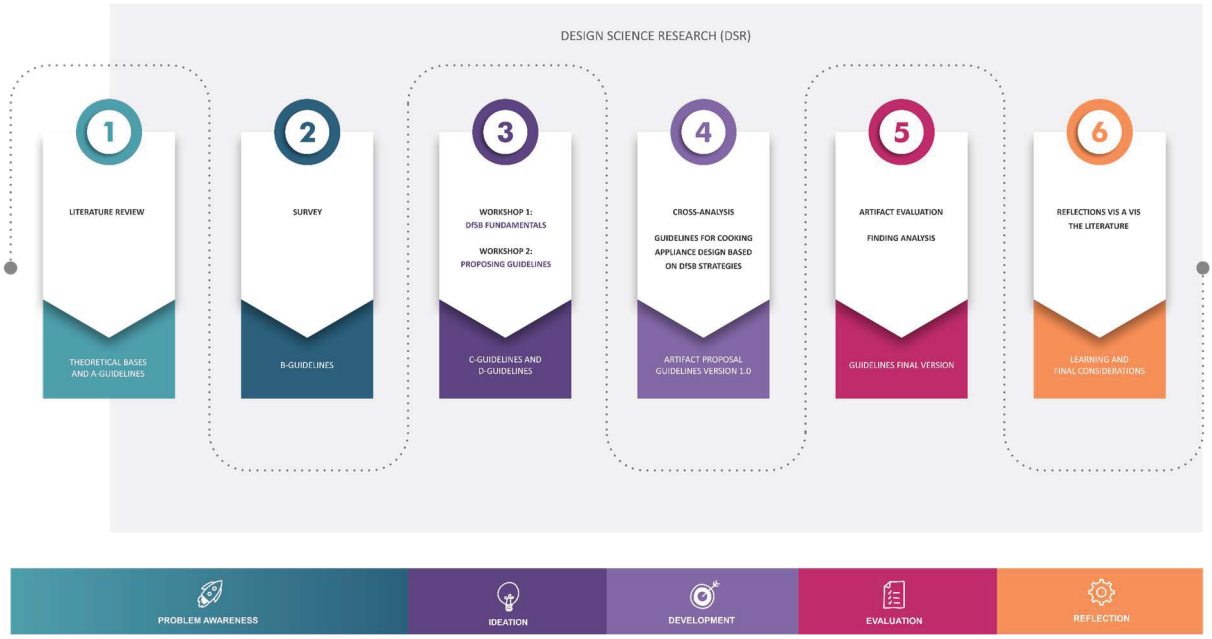
It is important to note that this study only emphasizes the white goods sector products associated with the home cooking activity, focusing on Design strategies to induce sustainable behaviour. Small appliances are not the focus of this research, only major cooking products such as stoves and cooktops.

1.7 METHOD OVERVIEW

The Literature Review and the Design Science Research (DSR) were the methods selected, considering the exploratory nature of this research. Dresch (2013) characterizes DSR as a method for developing and designing solutions to improve current systems, solve problems, or generate new artifacts to benefit the user's activities within the social or organizational context.

Santos et al. (2018) corroborates Dresch (2013)'s definition describing the DSR method as an approach which seeks to develop and evaluate the efficiency of an artifact for problem-solving aiming to understand "how it should be" instead of understanding "how it is". The research method here involves six steps, as shown in Figure 1.4.

FIGURE 1.4 - Research Method Overview



SOURCE: Author (2023)

Similar to the Design Process itself, the first stage of this method deals with "understanding the problem". It involved a Systematic Literature Review (SLR) consisting of a quantitative approach, which has an exploratory and descriptive nature and implied a critical analysis of the literature.

Seeking to identify Design for Sustainable Behavior strategies applied to products commercialized in Brazil, a Survey was carried out in the second phase, including members of the Brazilian Association of Electrical and Electronic Products Manufacturers (ELETROS). Its second part was carried out in order to identify Design for Sustainable Behavior practices on

a global level that can be replicated in the Brazilian context or gaps that might represent opportunities for the industrial sector. The comparative process, based on the guidelines established by McNair and Leibfried (1992) took place in three stages that involved planning, data collection, analysis.

The third phase of the research included two collaborative workshops with the household appliance company, Electrolux. The first workshop was dedicated to the alignment of scientific knowledge and industrial practices on Design for Sustainable Behaviour with the Electrolux Latin America Design team. Aiming at the co-creation of propositions for design guidelines, the second workshop was held with design experts responsible for cooking appliance development.

The guidelines were further developed in the fourth phase of the research method. A cross-analysis was performed, in a comparative and qualitative way, identifying similarities, particularities and gaps that resulted in version 1.0 of the guidelines.

The first artifact version was discussed and analyzed in the fourth stage of the research strategy. The analysis parameters focused on the alignment with the practice of developing cooking products, the corresponding stage of the design process, the support for the designer's decision-making, instruction for new designers, and contribution to the design team's learning.

The last stage involved reflection on the empirical results obtained vis-a-vis the reviewed literature, pointing out possible refinements in the guidelines and the potential repercussions in the household appliance sector, drawing on criticisms and suggestions from the Electrolux team. It culminated with a publication to guide the white goods sector in Brazil regarding the potential repercussions of the application of Design for Sustainable Behaviour strategies.

1.8 DISSERTATION STRUCTURE

The presented study covers a structure composed of 5 chapters described below:

Chapter 1 – Introduction: presents the introductory elements that guided the research development, such as context, research problem, objectives, justification, and delimitations of the research scope. The chapter concludes by introducing an overview of the research method applied and the structure of the chapters that comprise the dissertation.

Chapter 2 – Design for Sustainable Cooking: describes the theoretical basis reached from the literature review for this study. It includes the following topics: The role of Design in fostering sustainable behaviour; The cooking habit; Implications of cooking for sustainability; Sustainable Cooking and Design for Sustainable Behaviour applied to cooking products. The elaboration of this chapter presents definitions, concepts, principles, strategies, and limitations. It provides discussion from different points of view and identifies gaps. Finally, it amplifies scientific contributions and reveals the research problem.

Chapter 3 – Research Method: describes the research method adopted on this MSc dissertation, including the characterization of the research problem, the selection of the research method, the overall research strategy, the data collection protocol and the analytical strategy.

Chapter 4 – Research Results: analyses and discusses the results obtained through applying the research method.

Chapter 5 – Considerations and Future Work: indicates the final considerations, lessons learned, and opportunities for further research on Design for Sustainable Behaviour.

2 DESIGN FOR SUSTAINABLE COOKING

This chapter addresses an extensive literature review on Design for Sustainable Behaviour, Cooking Habits, and Household Appliances, sub-areas derived from the intersection of the major study fields presented in the research scope (e.g., in Fig 1.3 on p.28). These theoretical bases brought to light evidences and gaps that support the relevance of these topics and contributed to the development of the guidelines, which are the main objective of this study.

2.1 DESIGN FOR SUSTAINABLE BEHAVIOUR

2.1.1 The Role of Design in Fostering Sustainable Behaviour

According to Fiksel (2009) and Behera et al. (2012), sustainability is a process of change through innovation. It also requires alterations in activities, mental models, and behaviour (LOZANO, 2015; MEDEIROS et al., 2018). Design (and Designers) has a substantial potential contribution to direct such alterations as it is part of daily life in places such as home, work, leisure, education, health, sports, transportation, and the public environment. Individuals communicate with other people, define themselves in social groups, and demarcate their social status through products (BÜRDEK, 2006). The design of artifacts, either products, service or systems, does have a role in setting the direction of our opinions, attitudes and behaviour. Papanek (1971) points out that these artifacts have consequences that reach out into such diverse areas as politics, health, income, and the biosphere. Designers have shaped solutions that profoundly affect the environmental and socio-economical dimensions of sustainability (PAPANEK, 1971; LILLEY, 2009).

In the case of products, the decision-making taken throughout the design stages contributes to 70% of its impact (FABRYCKY, 1987; BHAMRA & LOFTHOUSE, 2007; ELIAS, 2011). Therefore, design plays an essential role in driving desirable or undesirable, intentional or unintentional change (NIEDDERER et al., 2014).

Human actions and the population growth have been generating a series of changes in the planet through the last decades, at different levels, such as the scarcity of essential resources like water, alteration of the nature cycles, extreme climate changes, illegal land

occupations, alteration of the soil, etc. (VEZZZOLI et al., 2018). The actions taken and the choices made by people have direct and indirect impacts on the environment, including personal and collective well-being (JACKSON, 2005).

The users' behaviour in the use stage depends on their preferences and habits. Whereas there is an unconscious relationship between the user's expectations and the configuration of the artifact, designers can manipulate it (PAPANEK, 1971). It could influence a more sustainable awareness or more sustainable behaviours in an ethical approach. Both terms have different meanings. Awareness by itself does not imply a behavioural change, dealing directly with opinions and perceptions about the implications of our own behaviour and the behaviour of others. Behaviour on the other hand means an action that, once repeated, becomes a habit that can foster lasting socio-cultural change. By considering the use phase of products, designers have great potential to decrease negative environmental, social (BHAMRA et al., 2011) and economic impacts.

Design solutions take part in human action as drivers of routine activity. It means that they have a co-responsibility for how the action develops and for what results. If users produce waste in everyday actions, such as within the household, this has to do with the way artifacts guide them (JELSMA, 2006). Hence, designers are co-responsible for the relation between individual life's quality and the socio-economic-environmental legacy to future generations, the center of sustainable development (CESCHIN, 2010; VEZZOLI et al., 2018).

By recognizing his/her/their share of responsibility and taking into account the inter/multidisciplinary nature of the area, Design can extract from behavioural studies the necessary subsidies for a new approach under the umbrella of Design for Sustainability, known as "Design for Sustainable Behaviour" (DfSB). Niedderer et al. (2014) emphasize that this thinking in the design process considers actions and services associated with any design and its contexts and consequences.

To achieve a more sustainable society, the designer as a professional can work towards influencing changes in user behaviour by merging the satisfaction of human needs with sustainable development. Such contribution is enhanced if decisions are made at a strategic level prior to design development (LILLEY, 2009).

Several authors highlight the variety of possibilities on how design can contribute to more sustainable behaviour, as illustrated in Table 2.1.

TABLE 2.1 – Examples of Design Influence to Achieve Sustainable Behaviours

AUTHORS	DESIGN SKILLS
Jackson (2005)	- Understanding whether the behaviour change is one-off (buying an energy-efficient appliance, for example) or involves changing behaviour routines (such as turning off the lights).
Bhamra & Tang (2008)	- Identifying what shapes consumer decision-making behind the operation of products in order to detect what influences people to reduce the use of energy sources.
Vezzoli et al. (2018)	- Developing systems focused on the complete satisfaction of the user's needs and wishes through harmonious solutions according to the pillars of sustainability, promoting long and healthy life.
Sampaio et al. (2018)	- Designing new products and services, redesigning or even identifying new social demands that promote the inclusion of disadvantaged populations through collective rather than individual solutions.
Santos et al. (2018)	- Understanding sociological and psychological aspects, globalization, local cultures, and socio-environmental impacts. - Promoting access to a dignified life and empowerment of the local community. - Developing products and services through an ethical, empathetic, and responsible lens.

SOURCE: The author (2023)

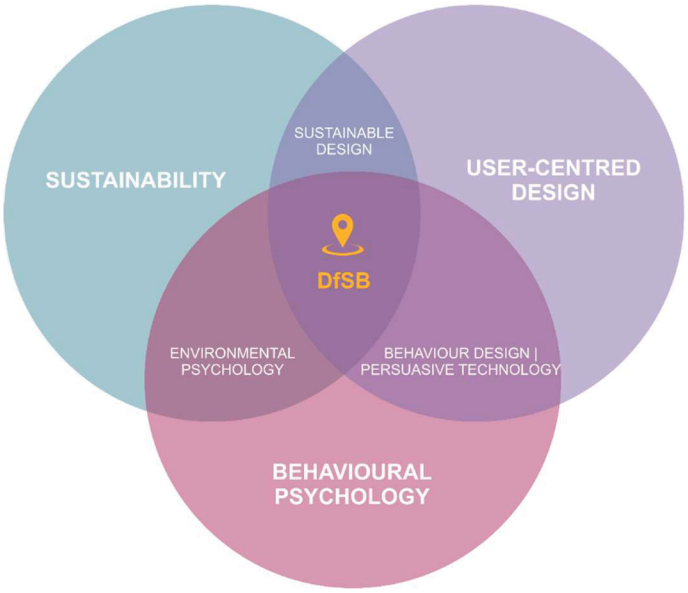
The responsibility of designers for the impacts caused by user behaviour puts design at the center of reflections on its role as an influential agent of behavioural changes, impacting ethical and innovative transformations (NIEDDERER et al., 2014; MOTA & COSTA, 2016). Through the adequate choice of methods, tools, concepts, principles and models, designers can influence how people make decisions when interacting with products, services and systems. Once fulfilling this potential capacity, the designer will influence attitudes, behaviours and, ultimately, change unsustainable habits, driving more responsible production and consumption. Ultimately, these changes will reflect on the adoption of more sustainable lifestyles (SHERWIN & BHAMRA, 1998; BHAMRA & LOFTHOUSE, 2007), in line with the requirements to reduce the anthropogenic causes of climate change.

2.1.2 Defining “Design for Sustainable Behaviour”

Biology, psychology, society, and culture drive the interaction between people and products, resulting in sustainable or unsustainable behaviours (NORMAN, 2002). Consumer behaviour, as suggested by Bhamra et al. (2008), determines the impacts emerging from the use stage. Conventionally, the search for sustainable consumption largely focuses on purchasing behaviour and not so much on the usage stage. However, consumption involves not just purchasing but developing routines and rituals of use and modifying the product tangibly or symbolically (BHAMRA et al., 2011).

Design for Sustainable Behaviour (DfSB) is an approach within the broader field of Sustainable Design seeking to reduce socio-environmental and economic impacts by moderating how users interact with products (BHAMRA et al., 2011). Its position has been placed by intersection of three main study areas: Design, Sustainability & Behavioural Psychology, demonstrated in figure 2.1.

FIGURE 2.1 - Theoretical position of Design for Sustainable Behaviour



SOURCE: The author (2022). Adapted from DAAE (2014).

DfSB arises from the responsibility assumed by designers on the interaction between users and products, triggering actions that bring positive or negative environmental, social and economic impacts (JELSMA, 2006; CESCHIN & GAZIOULUZOY, 2020). Indeed, Lilley (2009) and Wilson (2013) agree that DfSB is a branch of sustainable design theory concerned with applying strategies that attempt to influence consumer behaviour during the use phase.

Similarly, Ceschin & Gaziouluzoy (2020) define DfSB as the study field focused on how design can shape or influence human behaviour for health, safety, and social benefit reasons to support the adoption of more sustainable innovations. When DfSB strategies are applied to the interface between users and their goals, the artifact can be designed to shape an individual's perception, learning, and interaction (TANG & BHAMRA, 2008). It allows designers to challenge an individual's intentions, facilitating conditions and habit formation (WILSON, 2013).

Bhamra et al. (2008; 2011) argue that a user-centered methodology is essential for understanding the complexity behind the interaction of users, artifacts, and the context where they are placed. Designers must examine users' experiences, motivations, and needs (REDSTRÖM, 2006). It is necessary to stimulate new habits, and user-centered sustainable solutions aiming to change the user profile into a more sustainable direction (WEVER et al., 2008). Also, Wever et al. (2008) advocate a user-centered Design for Sustainable Behaviour to encourage industries to design products to persuade people to use them in a sustainable friendly way (NIEDDERER et al., 2014).

Analogous to the characterization of Design for Behavioural Change (DfBC) proposed by Mota & Costa (2016), the following elements can define the domain the anthropocentric perspective of DfSB:

a) Basis in behavioural theories;
b) User-centered methodology;
c) Designers' ethical responsibility, and
d) Sustainable innovation in the use phase.

Approaches and tools on Design for Sustainable Behaviour have been built on four basic principles (Niedderer et al. 2014):

a) Enabling people to adopt the desired behaviour;
b) Imposing difficulties on people to perform an undesired behaviour;
c) Making people want the desired behaviour;
d) Preventing people from wanting an undesired behaviour (NIEDDERER et al., 2014; CESCHIN & GAZIULUSOY, 2016).

On the process of implementing such principles Lilley (2009) emphasizes that influencing user behaviour can be a challenging, particularly in terms of ranking which types of behaviour warrant more forceful interventions and what is an acceptable level of

intervention. Behaviour interventions through Design can be described by different models and reviewed under different frameworks. The effectiveness of a model depends on the problem as defined. Different challenges can be framed concerning a particular behaviour, which will not necessarily apply to other behaviours (CHATTERTON & WILSON, 2014).

Bhamra et al. (2011) argue that Design for Sustainable Behaviour can be applied in order to induce users towards more sustainable usage habits. Vezzoli et al. (2021) defend that DfSB also plays a crucial role in promoting Sustainable Product-Service Systems (S.PSS), because of its ability to influence new habits and its focus on sustainable innovation. Indeed, some S.PSSs solutions require significant changes in consumption patterns and user habits, engaging consumption grounded on access and sharing of goods, such as vehicles for urban mobility. However, Vezzoli et al. (2021) report that S.PSSs offerings oriented to sharing goods still have to face barriers in product categories such as appliances. This context encourages the application of DfSB to support solutions that stimulate these changes (VEZZOLI et al., 2021).

2.1.3 Brief Historical Context

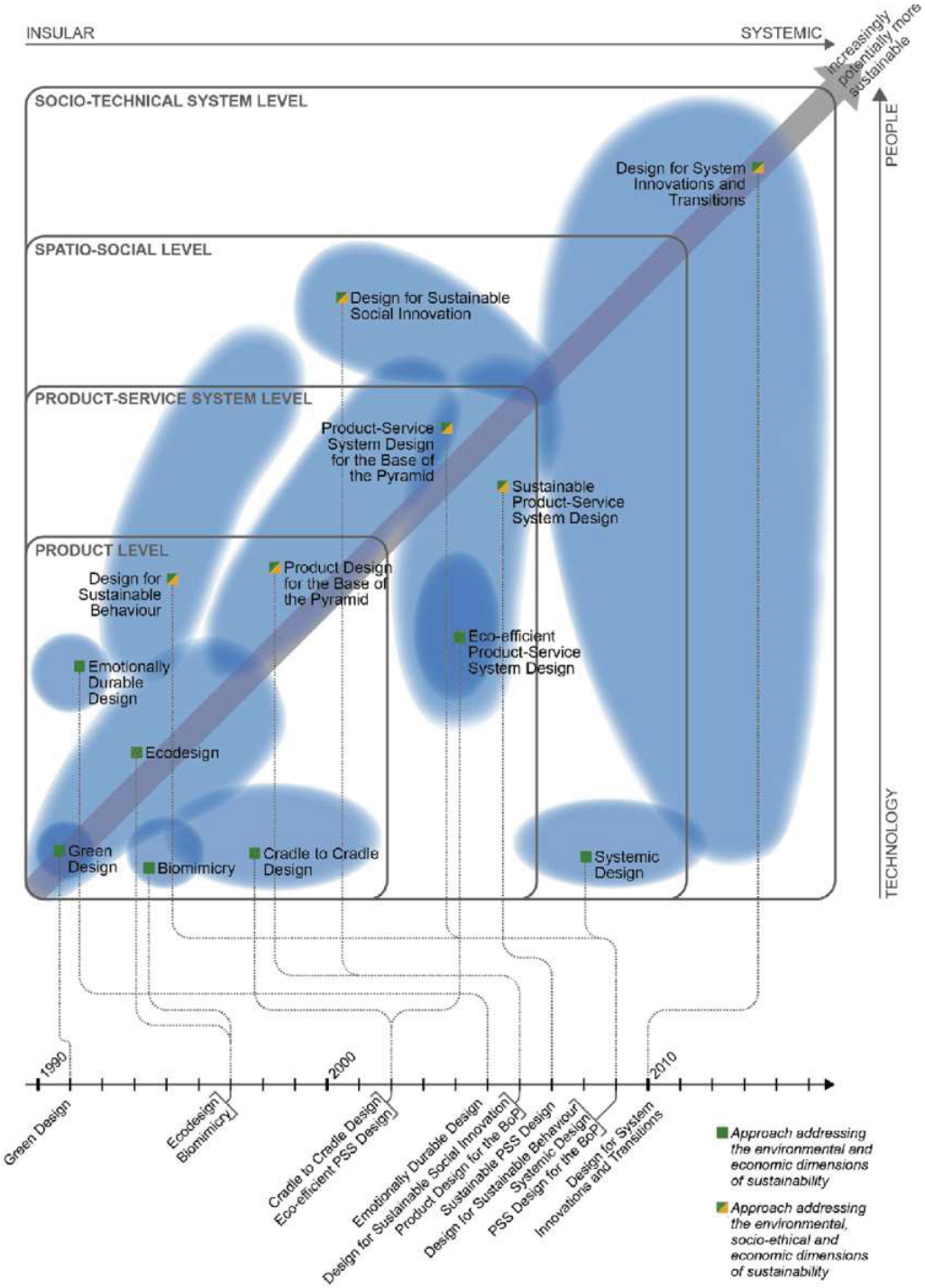
As reported by Ceschin & Gaziulusoy (2020), the influence of design in achieving more sustainable behavior began to be investigated in the second half of the 2000s, since the Design for Behaviour Change approach does not necessarily take sustainable dimensions into account. The first studies of Rodriguez & Boks (2005), Lilley (2007, 2009), and Wever et al., (2008) allowed the development of approaches, strategy models, and tools that have been applied in several types of research (CESCHIN & GAZIULUSOY, 2020).

Design for Sustainability, as a general subject, is firstly discussed by technical areas such as Mechanical Engineering, and its first efforts focus on product and life cycle aspects (WEVER et al., 2008). Several tools and strategies in this field have aimed at reducing environmental impacts. However, the efforts coming from this initial work are not enough if the impacts caused during the use phase are not considered. In contrast, DfSB places the user as the core of sustainable change and positions the designer as an agent of cultural transformation.

Under the Design for Sustainability context, DfSB is a human-centric framework that provides interventions in products, product-services systems, and social innovation, extending

its coverage to the three pillars of sustainability. Designers are now considered as a key agent of sustainability by taking into account the impact of their behaviour on sustainability during the use phase of the artifact. Figure 2.2 shows the DfSB approach's level regarding the other Design for Sustainability approaches and its evolution in a more sustainable way, drawn up by Ceschin & Gaziulusoy (2016).

FIGURE 2.2 - The Design for Sustainability Evolutionary Framework



SOURCE: Ceschin & Gaziouluzoy (2016)

Seeking to map the research associated with DfSB, Spencer et al. (2015) provide a list of relevant studies (Table 2.2) drawn on behavioural theories that have been developed and contributed to the field of DfSB advancement in a short space of time.

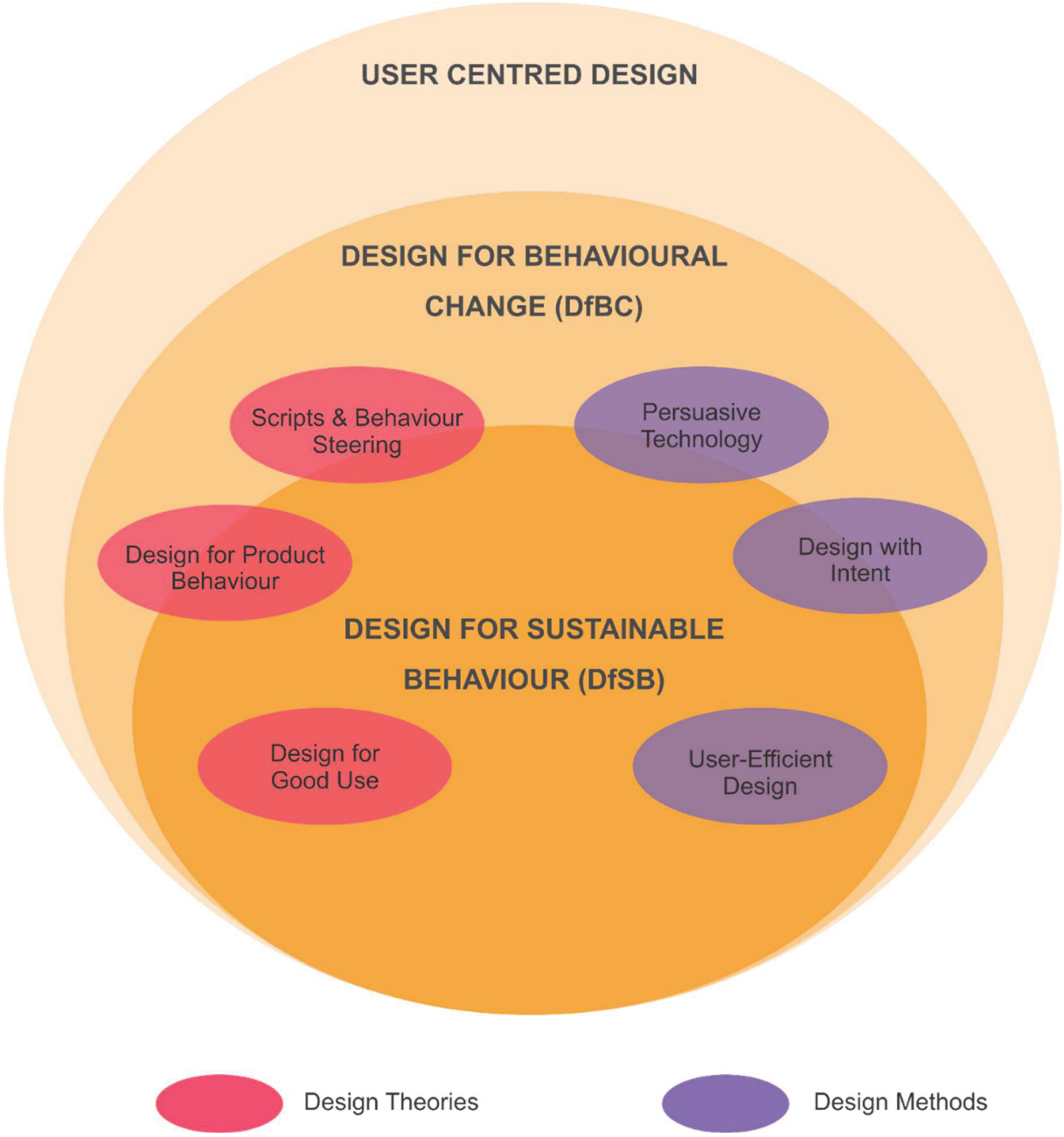
TABLE 2.2 – Design for Sustainable Behaviours Theories

YEAR	AUTHORS	DfSB THEORIES
2007	LILLEY, D.	Develops axis of control using feedback, steering & technology.
2008	WEVER, R., VAN KUIJIK, J. & BOKS, C.	Develops forced functionality concept as well as 2nd branch of model; functionality matching.
2008	ELIAS, E., DEKONINCK, E. & CULLEY, S.	Argues each behavior has a theoretical minimum energy requirement.
2008	TANG, T. & BHAMRA T.	Develops strategies further and integrates Triandi's TIB model (1977) and Anderson's framework for the acquisition of cognitive skills (1982).
2010	LOCKTON D., HARRISON, D. & STANTON, N.	Introduces real-world examples through a series of lenses to inspire designers.
2011	LIDMAN, K., RENSTRÖM, S. & KARLSSON, I.	Develops Tang (2010) & Wever et al (2008) models further with enlighten, spur, steer, force and match.
2012	ZACHRISSON, J. & BOKS, C.	Uses the axis but builds in further antecedents and factors such as values/norms, intention/constraints & importance/annoyance to guide change.
2013	WILSON, G.	Proposes user-centred method to create interventions based on DfSB strategies & framework to assess successfulness of DfSB interventions.
2013	RENSTRÖM, S., STRÖMBERG, H., & SELVEFORS, A.	Develop the 5 pathways model to aid selection of DfSB strategies at the start of a design project.
2013	LILLEY, D. & WILSON, G.	Integrates evaluation criteria and ethical assessment tool.

SOURCE: Spencer et al. (2015)

Several research studies were carried out since the first decade of the 2000s investigating the influence of human behavior (ELIAS, 2011) and its impacts on sustainability within User-Centered Design. Figure 2.3, adapted from the mapping developed by Elias (2011), shows these theories and methods.

FIGURE 2.3 - User-centred Design context



SOURCE: The author (2022). Adapted from Elias (2011).

The Scripts & Behaviour Steering theory introduced by Jelsma (2000) is associated with the concept that products and technologies have a script and can prescribe the actions of the

actors involved (AKRICH, 1992; LATOUR, 1992; JELSMA & KNOT, 2002; VERBEEK & SLOB, 2006; ELIAS, 2011).

Proposed by Fogg (1999), Persuasive technology as a method explores the context of site and computer software design, representing a significant potential for improving computers' environmental impact and derivatives. Persuasive technological experiences can come from: the Internet, video games, cell phones, and even specialized consumer electronic devices, etc. (ELIAS, 2011).

Design with Intent is a collection of examples of how product design and the environment affect people's behavior intentionally and unintentionally. From these examples, Lockton (2009) built a toolkit to help designers influence behavior (ELIAS, 2011).

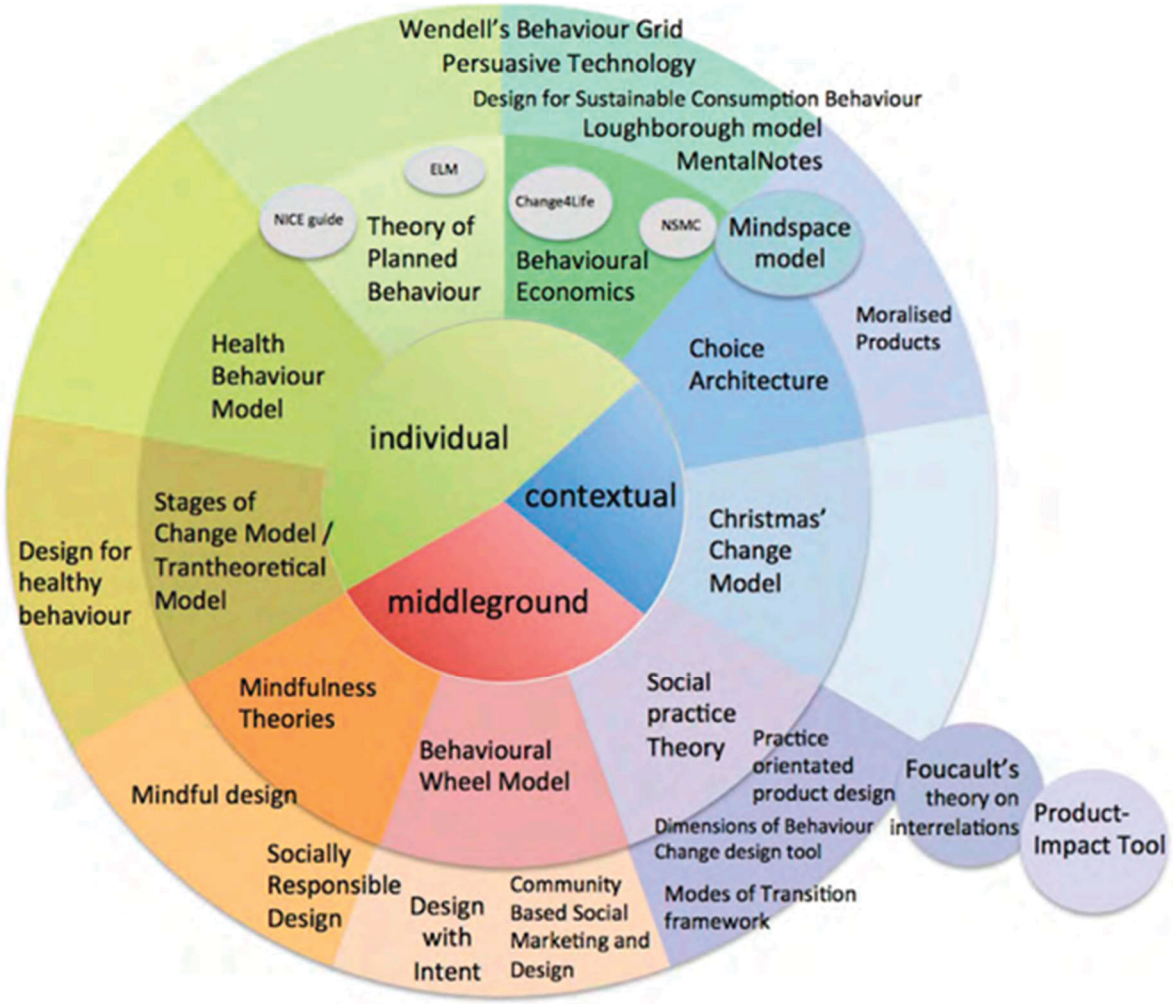
The Product Behavior Theory (ELIAS et al. 2007, 2008, DEWSBURY et al. 2001, ORPWOOD et al. 2005, STEFANOV et al. 2004) aims to use product design and features to avoid misuse by users, achieving positive results for the environment in an autonomous way. Medical studies analyze the use of automated and assistive technology for patient care at home. This theory can contribute, for example, to the development of IoT (Internet of Things) products oriented to a smart home for people with special needs.

The Design for Good Use approach explores the environmental impact from the perspective of equipment use in office environments that were previously unconsidered compared to industrial activities that produce larger impacts. This approach deals with improvements toward the eco-efficiency of products in the use phase (ROZO et al., 2009). Finally, Elias (2011) defines User-Efficient Design as an approach in user behavior aimed at optimizing the energy efficiency of products.

2.1.4 Theories and Strategies on Design for Sustainable Behaviour

Design for Behaviour Change (DfBC) is grounded in a number of theories, approaches and tools developed to stimulate sustainability-friendly actions and lifestyles (NIEDDERER, 2014). Built on the foundations of numerous behavioural theories, Niedderer (2014) classifies approaches in DfSB into three categories: individual, contextual and middle ground, as shown in figure 2.4.

FIGURE 2.4 - Categorization of approaches in relation to behavioural theories



SOURCE: Niedderer et al. (2014)

The theoretical models related to individual rational choice focus on decision-making and actions of users independently, grounded in the cognitive bias. The models categorized in the contextual group understand the user's behavior due to the context of the social structure in which individuals are placed. Finally, in the third category, the models are classified as middle-ground since they mix the individualistic rational choices with the contextual approaches (NIEDDERER et al., 2014; CESCHIN & GAZIOULUZOY, 2020).

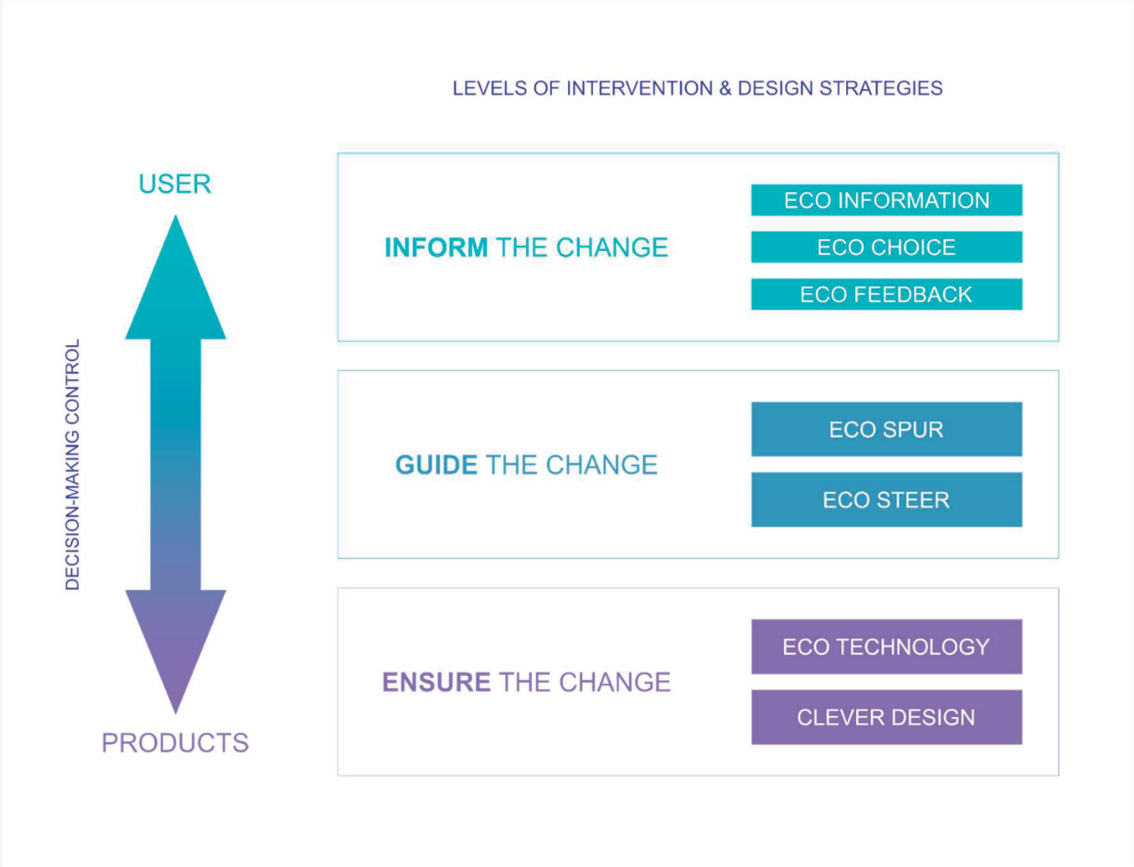
DfSB aims for sustainable habits and includes behavioral research, pragmatic development of products and services, and careful data analysis (WENDEL, 2014; MEDEIROS et al., 2018). By understanding the current habit, DfSB allows establishing a new behavior through the application of strategies combined with an efficient design (BOKS, 2012; LOCKTON & HARRISON, 2013; MEDEIROS et al., 2018). Wever (2012) and Medeiros et al. (2018) point out that the main approaches of DfSB focus on the following topics:

- The study of user mental models;
- The applicability of DfSB;
- The understanding of user behavior;
- The translation of perceptions to use in the early design phases; and
- DfSB interventions and evaluation of their effectiveness.

Regarding the theories illustrated in figure 2.4, this research adopts the Loughborough University model (BHAMRA et al., 2011) as a theoretical basis, detailed in the Research Scope, subtopic 1.6 of the first chapter. This model merges Lilley's (2007) studies on user control and decision-making with the strategies developed by Tang & Bhamra (2008). The reason for selecting this model is that it presents a good diversity of interventions (7) that have already been tested and discussed by other authors in this field during the last decade.

The DfSB model developed by Loughborough University (BHAMRA et al., 2011) is based on behavioral economics and offers strategies capable of informing, guiding, or ensuring more sustainable actions through artifacts developed, focusing on the individual (CESCHIN & GAZIULUSOY, 2016; 2020). It is represented in figure 2.5 below.

FIGURE 2.5 - Loughborough University DfSB Model (2011)



SOURCE: The author (2022). Adapted from Bhamra, Lilley & Tang (2011).

From the understanding of the axis of influence developed by Lilley (2007) focused on the control of decision-making and its relationship with the level of intervention, designers can select the strategies proposed by Tang & Bhamra (2008) to apply in the solution, aiming those which best fits the desired behaviour.

2.1.5 Limitations of "Design for Sustainable Behaviour

Although studies on DfSB keep growing, concerns have been raised that the limitations of these DfSB strategies are rarely discussed (WILSON et al., 2015; SHIN & BULL, 2019). There is a scarcity of metrics to measure the effect of applied strategies, and evidence-based examples are lacking (LIDMAN & RENSTRÖM, 2011; NIEDDERER et al., 2014). Further exploration of the field of DfSB is needed, especially to ensure strategies are effective and commercially viable in the long term to achieve sustainable impacts (LIDMAN & RENSTRÖM, 2011).

During the implementation of DfSB there are ethical implications that need to be widely discussed; including the responsibility of designers and companies in influencing behaviors (BERDICHEVSKY & NEUENSCHWANDER, 1999; BREY, 2006; BHAMRA et al., 2011; CESCHIN & GAZIULUSOY, 2016). Lilley & Wilson (2017) emphasize the importance of morality in decisions made by designers to understand the ethical repercussions that encompass this study area and identify relevant theories to build valuable and comprehensive tools for designers. Bhamra et al. (2011) note that some studies (LILLEY & LOFTHOUSE, 2010) address this gap. Still, their own research has focused on this topic using studies that explore technology and ethics in other fields (BERDICHEVSKY & NEUENSCHWANDER, 1999; BREY, 2006; DEVRIES, 2006; VERBEEK, 2006), as the design literature is scarce (FIALKOWSKI & SANTOS, 2019).

Wever et al. (2010) and Ceschin & Gaziulusoy (2016) alert scholars that the use of additional materials and resources during the Design process through DfSB may cause environmental impact larger than the supposed environmental gain. Furthermore, companies may not adopt DfSB strategies considering that investments do not result in immediate gains (LILLEY, 2009; NIEDDERER et al., 2014; CESCHIN & GAZIULUSOY, 2016). Further limitations include: the risk of failing to achieve an intended behaviour and the obsolescence of an

intervention, and questions regarding how the intentional behaviour can be reproduced, maintained, and internalized remain (SHIN & BULL, 2019).

2.2 THE COOKING HABIT

2.2.1 Definition of Cooking

The etymological origin of cooking derives from the Latin word *coquus*, which has as one of its meanings "to submit to the action of fire" (THE OXFORD DICTIONARY OF ENGLISH ETYMOLOGY, 1966). From an anthropological perspective, habitus represents a set of behaviours, based on sociocultural norms, which are repeated by one or more individuals in a society, defining what it is to be in the world and the feeling of belonging for different groups of people (BORDIEU, 2004; GARCIA, 2019). Beyond the literal or semantic meaning, this topic explores the context and culture of cooking habits, methods, and appliances that have influenced people's behaviour so far.

As a consequence of the fire control (BYRD & DUNN, 2021), the cooking activity (BYRD & DUNN, 2021) distinguished the human being as an animal that cooks (KATZ & WEAVER, 2003; BOSWELL, 1785). It has modified the natural properties of food through heat and have benefited human evolution (FLANDRIN & MONTANARI, 1998), characterizing a progress for health and welfare (BYRD & DUNN, 2021).

In contemporary times, the cooking task has incorporated new values and practices, in addition to meeting physiological needs or learning how to cook. It plays an essential role in the constitution of relationships and identities, individual and collective, provided by home habits (BELL & VALENTINE, 1997). Indeed, globally, women cooked more meals compared to men. The gender gap in cooking frequency is widest in countries in the Commonwealth of Independent States and the Baltics, the Middle East, North Africa, Asia, and Latin America, where overall gender inequality is more prominent (GALLUP, 2021).

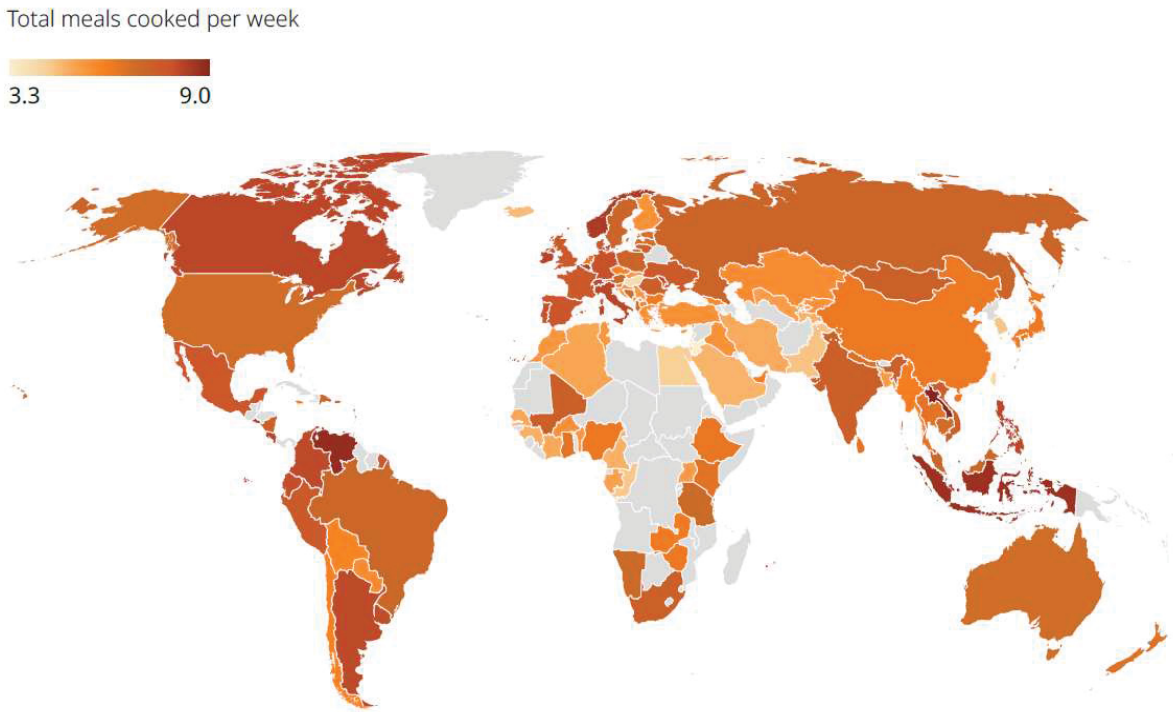
However, on the aftermath of the worst part of the COVID-19 several studies indicated a steady decline in household meal preparation (KOLODINSKY & GOLDSTEIN, 2011; POLLAN, 2013; PLESSZ & ÉTILÉ, 2019; SARDA et al., 2022). Lack of time (LAVELLE et al., 2016), the wide range of ultra-processed foods, low-cost products (SMITH & POPKIN, 2013; THARREY et al., 2020), the decline of cooking traditions and skills (CARAHER & LANG, 1999), as well as limited

food resources (WOLFSON et al., 2020) are some of the reasons for it (SARDA et al., 2022). In addition, Hart (2019) includes the abundance of convenience, frozen ready foods, an increase in takeout options, and unlimited dining out options as reasons for the decline in cooking habits.

2.2.2 Factors Affecting Home Cooking Habits

Since 2020, the pandemic of COVID-19 highly impacted decision-making and food consumption. The restriction measures recommended by WHO (2020) triggered an increase in household time, representing an opportunity to change cooking habits (SARDA et al., 2022). Gallup (2021) reveals that the world cooked 6.7 meals per week in home, and the most significant regional growth during the pandemic was in Northern America, Latin America, and Europe, where people reported 0.6 extra meals per week. Figure 2.6 illustrate the average of meals home-cooked per week worldwide.

FIGURE 2.6: Average of meals home-cooked per week in 2020



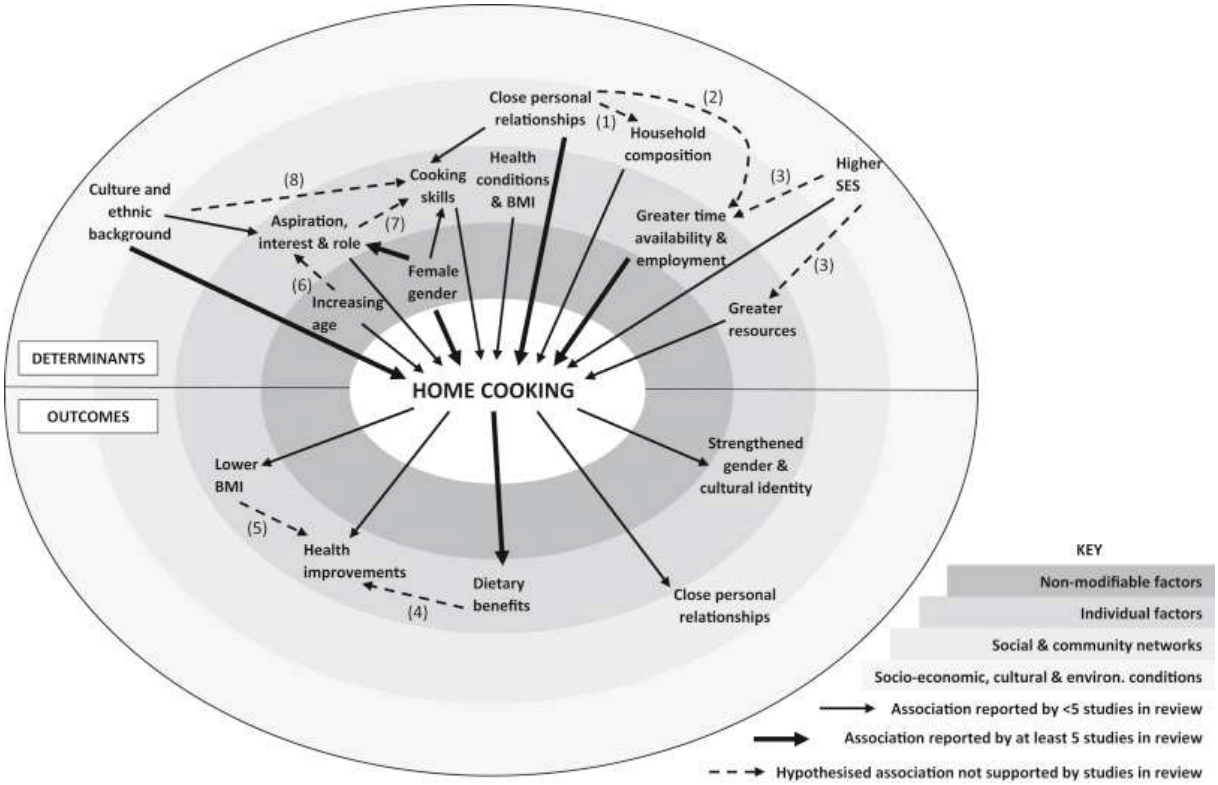
SOURCE: Gallup (2021)

According to Frankowska et al. (2020), cooking food at home, aiming at more sustainable methods, can reduce negative impacts compared to the consumption of ready

meals. However, the increase of meals at home during the Covid-19 pandemic may have caused harmful impacts on healthier habits practiced before it, especially in issues related to weight gain and increased risk of obesity (SARDA et al., 2022).

There are significant factors that can impact the behaviour and habits associated with cooking. In the case of home cooking, Mills et al. model (2017), as demonstrated in figure 2.7, identified many interrelated influences on perceptions and practices, supported by different levels of research evidence. Their observational study suggests that home cooking can offer positive outcomes regarding personal relationships, cultural identities and better indicators for healthier eating.

FIGURE 2.7: Health and social determinants and outcomes of home cooking



(1) Office for National Statistics, 2014, (2) Wepfer, Brauchli, Jenny, Hämmig, & Bauer, 2015, (3) Galobardes, Lynch, & Smith, 2007, (4) World Health Organization, 2003, (5) World Health Organization, 2015, (6) Macmillan & Eliason, 2003, (7) Caraher & Lang, 1999, (8) Jaffe & Gertler, 2006.

SOURCE: Mills et al. (2017)

Determinants of habits on home cooking are more complex than simply possessing cooking skills, and critical issues affecting behaviour are gender, personal relationships, time and job availability, ethnicity, and culture (MILLS et al., 2017).

In addition to the context's influence, cooking habit is also guided by cultural aspects that carry the marks of a people and their history, as emphasizes Montanari (2013).

One of the biggest factors that affects behaviour is the user cultural context (SPENCER et al., 2015). Cooking culture denotes a constant change through which methods are invented, preparation modes are individualized, and traditions are sculpted (CERTEAU et al., 1998). Similarly, Maciel (2004) argues that cooking implies choices, classifications, and symbols that organize the various worldviews in time and space. Cooking represents a language (LÉVI-STRAUSS, 1968), a communication vector (MACIEL, 2004). This complex code allows understanding the mechanisms of the society to which it belongs, from which it emerges, and which gives it meaning (MACIEL, 2004). For instance, according to Bell & Valentine (1997), the transmission of cooking values throughout history has been achieved through the habit of sharing recipes between generations, reproducing their "identities". Each cook adds prejudices and limits, preferences and routines, dreams and phobias to their repertoire (CERTEAU et al., 1998). Women were more likely to pass on their skills to their descendants (CARAHER et al., 1999, MILLS et al., 2017), especially girls, because cooking still is considered a female task (BANERJEE-DUBE, 2016; GALLUP, 2021; MILLS et al., 2017; POLLAN, 2013; WRANGHAM, 2009).

Current urban life has made regionalism even more challenging to reproduce, and the cultural identity loses its traces over time. Certeau et al. (1998) point out that regional dishes most often come from rural habits and require long, slow, and constant cooking. Neither the schedules nor the appliances of urban life are suited for it. Some traditions require searching for rare and expensive ingredients and demand long preparation times (CERTEAU et al., 1998). Similarly, Katz & Weaver (2002) argue that overall, people have lost culinary skills and knowledge, but as a result of a massive flow of information, the quest for healthier eating and, on the other hand, the convenience of unhealthy junk foods.

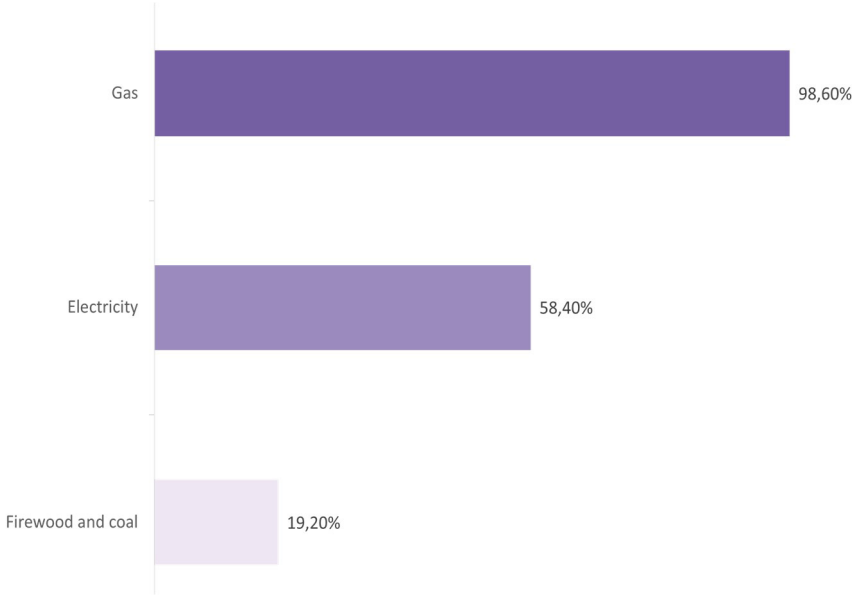
Banerjee-Dube (2016) argues that food and cooking - in different societies and eras - result from a combination of ingredients, ideologies, creativity, and power relations. This mix makes possible converging food and cooking stories that speak to being and belonging, pride, identity, hospitality, sociability, class, power, and nations (BANERJEE-DUBE, 2016; BELL & VALENTINE, 1997). A reflex of such context is individuals seeking in the cooking activity a way to express themselves creatively, following elaborate recipes, reflecting their cultural capital, elitism, and personal identities that distinguish them from the others. In contrast, the growth of small producers in many cities suggests cultural trends related to more sustainable diets and healthier food (GATLEY et al., 2014).

The cultural diversity in the cooking practice portrays the polyphony surrounding the variety of smells, tastes, peoples, and places. The attempt at global homogenization often erases them, which were a fundamental element in marking social distinctions (BANERJEE-DUBE, 2016; PETERS, 2016; PILCHER, 1998). Whilst there are countries easily recognized by specific ingredients, Brazil, due to its continental size and wide cultural diversity, presents peculiar and a high variety of habits and flavors in each region. These contextual and cultural aspects of Brazilian habits are presented in the following topic.

2.2.3 Brazilian Cooking Habits

Brazil comprises a continent-sized territory with approximately 217 million inhabitants (IBGE, 2022). It is a country with many social, economic, cultural, and climatic contrasts. Of its total population, 205 million people are distributed in 70 million residences throughout the 5 Brazilian macro-regions: North, Northeast, Midwest, Southeast, and South (IBGE, 2019). The cooking activity within these residences is still predominantly female, evidencing the high level of gender inequality. According to IBGE (2022), 95.5% of Brazilian women perform cooking tasks compared to 62% of men. This domestic practice constantly adds, besides food ingredients, the use of electricity, gas, and water, as well as kitchen appliances. The main fuel source for food cooking has been gas, present in 98.6% of homes, as shown in Figure 2.8.

FIGURE 2.8 – Percentage of households in Brazil per type of fuel used in food preparation



SOURCE: IBGE (2019).

According to the predominance of gas usage in the cooking task, it is not surprising that gas stove or cooktop are the main appliance used for home cooking, observed in 98.84% of Brazilian households (IBGE, 2019).

The cost of eating at home represents 14.2% of Brazilians' household income (IBGE, 2018). For families with incomes up to 2 minimum wages, the average expenditure on food compromises 22% of their monthly income (IBGE, 2018). Table 2.3 presents the average monthly expenditure on food, electricity, gas, water, sewage, and the acquisition of appliances by Brazilian families.

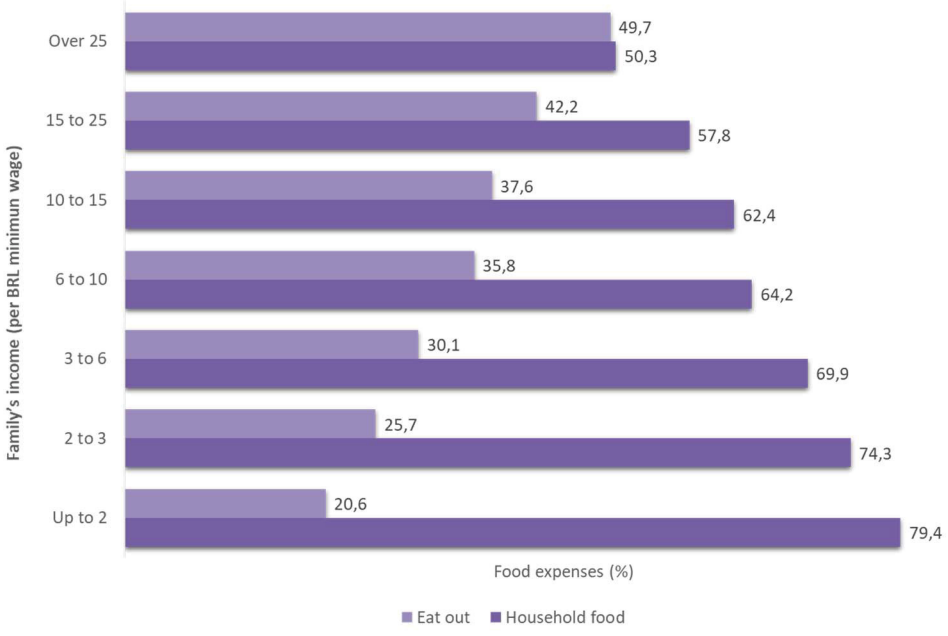
TABLE 2.3 – Monthly average expenditure per family's income in Brazil (%)

EXPENDITURE TYPE (%)	FAMILY'S INCOME (per BRL minimum wage)						
	Up to 2	**2-3**	**3-6**	**6-10**	**10-15**	**15-25**	**Over 25**
FOOD EXPENSES	22	19,1	17,1	13,8	12,2	9,9	7,6
ELECTRICITY	4,4	3,7	3,2	2,4	2,0	1,4	0,9
GAS	2,2	1,6	1,1	0,6	0,5	0,3	0,2
WATER AND SEWAGE	1,9	1,7	1,4	1,0	0,7	0,5	0,3
HOUSEHOLD APPLIANCES	2,3	1,9	1,6	1,3	1,1	0,9	0,6

SOURCE: Family Budget Survey, IBGE (2018)

In terms of food expenses, in all family income ranges, there is a prevalence of spending on home food (IBGE, 2018), as shown in graph 2.1.

GRAPHIC 2.1 – Monthly average expenditure on food in Brazil per family's income (%)



SOURCE: Family Budget Survey, IBGE (2018)

The contrast is notable among the lower income levels. Families with incomes up to three minimum wages spend more than 70% of their food budget on preparing domestic meals. A study by DIEESE (2022) indicates that 38% of Brazilians survive with a minimum wage of BRL 1,212. However, the minimum required to meet the needs of a family of four should be BRL 6,754.33.

Unfortunately, data from the family budget survey (IBGE, 2018) show that 73.77% of Brazilian families live below the minimum income recommended by DIEESE (2022). Thus, without the required financial resources to a dignified life, most families experience some level of food insecurity and do not have the power to choose the type of food suitable for a healthier and more sustainable diet.

The economic crisis, among other negative impacts caused by the inefficiency of public management in combating the COVID-19 pandemic in Brazil, has worsened the financial conditions for obtaining more sustainable food. Almost 55.2% of Brazilian residents lived with food insecurity at the end of 2020. Severe food insecurity, such as hunger, was present in 9% of residences, affecting 19 million Brazilians (PENSSAN, 2022).

The effects of the pandemic restrictions also resulted in significant changes in work routines, pushing 11% of Brazilian employees to work remotely (IPEA, 2022). New habits need to be taken into account, including cooking practice in the daily routine. It is estimated that new habits should be maintained by approximately 50% of new practitioners of home cooking who identified in this task the opportunity for healthier eating habits (FGV, 2021). The cultural cooking behavior of Brazilians is the subject of analysis in the next subtopic.

Brazilian cooking behaviour shows a strong influence from Portuguese colonizers as well as the habits Africans brought to the country during the slavery time (CIVITELLO, 2008). Indeed, Cascudo (2016) notes that Brazil's cuisine consists of a mix of European and African ingredients, but mainly indigenous ones. Part of the recipe ingredients and cooking techniques derive from the native people and, over time, have been modified by the Portuguese colonizers and enslaved Africans (CASCUDO, 2016).

Around 38% of the ten million enslaved people sent from Africa to the American continent went to Brazil, mostly to work in the sugarcane fields. Brazil's most famous dish, an elaborate black bean and rice dish with lots of meat, is a fusion of Old and New World foods and reveals the influences of enslaved people's cuisine in the use of pork cuts and the garnish of green leafy vegetables (CIVITELLO, 2008).

When exploring historical aspects of Brazilian food culture, Lopes et al. (2019) share the same thought as Civitello (2008) and Cascudo (2016). Lopes et al. (2019) state that the cultural cooking habits were spread among several generations, and popular manifestations have originated from the Indigenous, African and European ethnic mix, being intrinsically related to food consumption. The consumption of desserts after savoury meals, for instance, is an European habit that has been infused into Brazilian culture. The reproduction of European and African recipes from local fauna and flora ingredients gave Brazilian food unique aromas and flavours that acquired peculiar properties in each region of the country, influenced by various cultures (LOPES et al., 2019).

Throughout the 19th and early 20th centuries, Brazil became a destination for European immigrants from Germany and Italy who settled in the South and Southeast regions of the country and added their cultural influences the Brazilian food, particularly on those regions (CASCUDO, 2016).

At this point, MACIEL (2004) diverges about the contributions of immigrant ethnicities. The author argues that the highly valued cultural diversity in Brazilian cooking was a reflection of an unequal and hierarchical social order which imposed its culture over the local ones in a not at all harmonious way. For example, it is impossible to ignore that the Portuguese colonizer was the instigator of hierarchy, the black man was brought by force, and the native peoples were largely decimated (MACIEL, 2004).

Brazilian most popular dish is unanimously composed of rice and beans, whose preparation varies according to the region. However, the mixture of these two ingredients, very common in the Brazilian table, is not enough to summarize all the complexity and richness of the national cuisine (BRASIL, 2013). Each region of the Country has its peculiarity, due to the differences in climate, relief, type of soil, vegetation and the culture traditions of people living in the same region (BRASIL, 2013). It is very hard to establish only one typical Brazilian dish. The natural biomes influence the landscapes, the diversity of fauna and flora and the ingredients available to the Brazilian cuisine. Figure 2.9 illustrates the different biomes present throughout the extensive Brazilian territory.

FIGURE 2.9: Brazilian biomes

SOURCE: IBGE (2003)

The area covering the states of Acre, Amapá, Amazonas, Pará, Roraima, Rondônia and partially Mato Grosso (54%), Maranhão (34%) and Tocantins (9%) consists of the Amazon biome (IBGE, 2003). The Indigenous legacy strongly shapes the culture of this region. However, despite its Amazonian heritage, the regional cuisine was greatly influenced by Portuguese immigrants since the beginning of colonization (FREYRE, 2005). Later, along the rubber cycle, other people, such as Lebanese, Japanese, Italians, and even the Northeasterners, arrived and left their marks on the cooking culture. They migrated to the region in the same period (CASCUDO, 2016).

Having part of its territory been influenced by the sea and further enriched by the abundance of rivers, regional dishes blend the exuberance of the rainforest and the sea (BRAZIL, 2013). Cassava, among the most important ingredients in the history of Brazilian food, left the Amazon and gained the continent by adapting to the local soil and recreating its

textures, colours, aromas, and flavors (CASCUDO, 2016). The typical main dishes of the Amazon biome are baked, grilled, and cooked. Some food examples are Pato no Tucupi, Tacacá - hot broth served with Tucupi, dried shrimp, jambú, and tapioca gum -, Maniçoba - cassava leaves cooked for seven days and served with pork -, and Pirarucu de casaca - fish with flour (BRASIL, 2013).

The states of Ceará and partially Rio Grande do Norte (95%), Paraíba (92%), Pernambuco (83%), Piauí (63%), Bahia (54%), Sergipe (49%), Alagoas (48%) and Maranhão (1%) are included in the Scrublands biome (IBGE, 2003). As highlighted by the Guide of Brazilian Aromas, Colours and Flavours (BRASIL, 2013), the semi-arid climate of this region provides a perennial cuisine associated with food preservation, high-calorie contents, and resources for long journeys in search of water. Closer to the sea, dishes are rich in diversity of ingredients and colours, full of flavour.

Climate diversity has a direct impact on cooking. GOMES (2004) argues that the African legacy is more substantial from the coast of Pernambuco to Bahia due to the remnants of slavery during the sugar cane cycle. At Alagoas, seafood is more recurrent due to its various coastal lagoons. At Maranhão, the Portuguese influence is stronger than in the other states of the region, and the consumption of spicy seasonings, which are very common on the coast, is lower (CASCUDO, 2016). In the Northeastern backlands, the climate favours the consumption of meat, especially *carne-de-sol*, and dishes made with roots, mostly prepared through liquid cooking, frying, and roasting (GOMES, 2004). Creativity is notable in this area and is observed in typical dishes: *buchada de bode, carne de sol* with *pirão de coalho, paçoca de carne seca, baião de dois, tapioca; canjica, pamonha;* cakes; *escondidinho; tapioca*; cakes and *mocotó* sauce (BRASIL, 2013).

As defined by the IBGE (2003), the Cerrado biome concentrates the Federal District and part of the States of Goiás (97%), Tocantins (91%), Maranhão (65%), Mato Grosso do Sul (61%) and Minas Gerais (57%). Its climate is distinguished by two seasons: dry and rainy. The vegetation can reach dense forests and ciliary, which follow the water courses (IBGE, 2003). The local cooking is largely influenced by livestock, one of the main economic activities of this territory (CASCUDO, 2016). Typical dishes are largely prepared through liquid cooking. Rice with *pequi, picadinho* with *okra, empadão goiano*, cow *atolada; feijão tropeiro mineiro;* chicken with *okra; refogado de milho verde; tutu de feijão* and *torresmo* are the main foods that characterize the Savannah biome (BRASIL, 2013).

The area that comprises the Wetlands biome encompasses 25% of Mato Grosso do Sul and 7% of Mato Grosso. Within the Centre-West region, the Wetlands are the most extensive continuous floodplain on the planet (IBGE, 2003). From these areas, particular regional recipes emerge, with the typical main dishes being: *Caribéu* (stew of dried meat and manioc); *Chipa frita* (fried cured cheese and polvilho dumpling); *furrundu* (green papaya and rapadura candy); roasted *Pacu*, and *Piranha* broth (BRASIL, 2013). These preparations mainly require liquid cooking and roasting methods.

The states of Espírito Santo, Rio de Janeiro, Santa Catarina and partially Paraná (98%) are part of the Atlantic Rainforest biome (IBGE, 2003). The economic development in this biome reflects a prism of national and foreign cultures, singular and, at the same time, blended at the Brazilian food table (CASCUDO, 2016). Until the 19th century, the cooking of the Southeast was essentially influenced by Portuguese, Indigenous, and African backgrounds (CASCUDO, 2016). Simple foods such as roots, meats, grains and vegetables were spread throughout the Southeast territory, which made the gastronomy of each state become quite similar in ingredients and food preparation (MACIEL, 2004). The exception is the Capixaba cuisine, which, due to its proximity to the Northeast and large coastal area, has a strong presence of fish and seafood in the daily dishes.

With the arrival of Japanese, Lebanese, Syrian, Italian, and Spanish immigrants, the food diversity has expanded in the country, especially in São Paulo (CASCUDO, 2016). Prepared under liquid cooking, baking or frying, the typical dishes of the biome surrounding São Paulo consist of: *acarajé, cuscus, cocada*, shrimp in *jerimum*; *virado paulista, moqueca capixaba, feijoada, picadinho; doce de leite; pão de queijo; tapioca; bolo de rolo; bobó de camarão; bolinho de arroz* and *brigadeiro* (BRASIL, 2013).

The sixth Brazilian biome, known as the Pampas Biome, comprises 63% of the state of Rio Grande do Sul in the extreme South of Brazil (IBGE, 2003). Its rich countryside vegetation integrated with the Araucaria Forests and its geographical position and relatively low temperatures have created a culinary culture with strong colonial and cross-border influences (BRASIL, 2013). The ethnic mixture in the South region resulted in a completely different cuisine from the rest of the country, with an even stronger presence of Italian and German cooking and the already present Portuguese and Spanish influence (CASCUDO, 2016).

As exemplified in the Guide of Brazilian Aromas, Colours and Flavours (BRAZIL, 2013), the barbecue, main dish of Rio Grande do Sul state, resulted from a historical fact. To catechize

the indigenous people of the region during colonization, the Jesuit priests introduced cattle raising and left the animals under the responsibility of the natives. With the arrival of the Paulista and Minas Gerais' muleteers, who enslaved the Indians, the cattle remained loose in the fields and spread to the South, as there were no predators. Therefore, the abundance of pastures and the tradition of the gaucho barbecue remains today (BRASIL, 2013).

The Italian immigrants introduced pasta, polenta, and chicken into the regional eating habits and cultivated vineyards, which produce internationally awarded sparkling wines (CASCUDO, 2016). On the other hand, the German influence was restricted to the colonies in the interior of Rio Grande do Sul and Santa Catarina. Paraná, despite the strong Italian influence, also has a significant presence of indigenous cuisine, especially with roots and grains (BRASIL, 2013). The main delicacies of this biome, predominantly roasted or submerged in liquid cooking, are *cappelletti* soup; roasted *galeto*; barbecue; *sagu* with red wine; *barreado*; rice of *carreteiro* (BRASIL, 2013).

As this section showed, the cooking present in the Brazilian context are directly affected by a historical process that articulates a set of elements referenced on tradition, culture, local conditions, and the sense of creating something unique (LÉVI-STRAUSS, 1968; MACIEL, 2004; FREYRE, 2006; BRILLAT-SAVARIN, 2009; CASCUDO, 2016). These cultural identities denote a permanent reconstruction, transformations, and re-creation of Brazilian cooking habits. Therefore, cooking meals in the country cannot be reduced to an inventory, to a repertoire of ingredients, nor converted into formulas or combinations of elements crystallized in time and space (MACIEL, 2004). The cultural influence present in the beliefs and traditions of each people results in the improvement and development of new cooking techniques that will be discussed in the following topic.

2.3 COOKING METHODS

The human species has explored different ways to prepare food to meet its survival needs and satisfy their pleasures. This relationship was influenced by regional and technological characteristics over time, with primitive technology acquired and accumulated through empirical knowledge without a scientific basis (ROSENBERG, 1982). The cooking techniques allowed transforming the elements to facilitate the daily tasks, rationalizing and

understanding the procedures involved (KENSKI, 2012). Moreover, the methods adopted can sterilize and change foods' textures, flavours, and colours (BARRETO, 2002).

As stated by Katz & Weaver (2002), the basic cooking techniques depend on three modes of heat transfer: radiation, conduction, and convection. These modes employ different mediums, mostly water, oil, or air (Katz & Weaver) which produce different results for each type of food (BARRETO, 2002). In contemporary times, gas, electricity, induction plates, and electromagnetic waves are the main sources used for heat transfer (TEICHMANN, 2009).

Many techniques, including grinding, sifting, drying, salting, sealing, fermenting, and applying heat, are extremely ancient (KATZ & WEAVER, 2002). The first, still rudimentary, cooking methods were carried out by placing the food directly over the fire. The techniques developed during the pre-historical period include: placing the food on a hot stone; packing the food with grass, mud, or animal skin before baking; burying raw material in hot ashes or stones to cook the food (ZHOU et al., 2020). Few fundamentally new techniques have been introduced in the past two centuries, among them microwaving (KATZ & WEAVER, 2002).

The classic heat cooking methods are described in detail by Franco (2017), Cascudo (2016), Coletti (2016), Domene (2011), Evangelista (2008), Barreto (2002), Katz & Weaver (2002), Castelli (2001), Flandrin & Montanari (1998) and Lévi-Strauss (1964), as well as categorized into dry heat, moist heat and mixed heat, to be explained in the following.

Cooking by dry heat can use fat, transmitting heat indirectly to the food. It is exemplified by the techniques of sautéing (high temperature, pan uncovered and continuous stirring), frying (cooking with little fat and no stirring), low-fat frying (very hot temperature and no immersion) and deep-frying (immersing the food in a large amount of fat). Dry cooking can also occur without the use of fat, using only dry air as in the methods of oven baking (hot air and direct heat evenly distributed), open air baking (hot air and direct heat), grilling (high temperature) and smoking (exposing the food to smoke from burning).

In contrast, moist cooking uses water, steam, or another type of liquid to soften food fibers and is, therefore, the slowest technique. This cooking method is done by steaming (without contact between the food and the liquid) or cooking in a liquid (immersed food). Liquids commonly used are water and salt, sauces, and milk. Examples of steam cooking include:

- Pressure cooking using pans with specific sealing systems, resulting in a quick and economical method;

- Pressureless cooking consists of cooking the food in the steam of the boiling liquid, separated by grills on the bottom of the pans. It preserves most of the nutritional, taste, colour, and texture properties of the food;
- *Papillotte*, the cooking of pre-seasoned food wrapped in aluminium or waxed paper, pre-greased, and placed in a hot oven. In this case, the cooking steam comes from the food's liquid.

Finally, there is mixed heat cooking which takes place in two stages. Firstly, the preparation is sealed by applying dry heat with fat, protecting the food, so its juices are not wasted. Secondly, the liquid is added, depending on the technique employed. The mixed heat cooking methods are:

- Stew, in which the food is chopped and exposed to little liquid;
- *Poêter* uses a closed saucepan, fat, and low temperature.
- Braising consists of browning the food in an oval pan with side handles, covering in a hot fat before liquid cooking.
- *Saute* consists of frying in little fat with a lid and cooking the food with the steam released over low heat.
- Soaking means *sautéing* the food in hot fat and adding liquid later for cooking with a closed pan.
- Steaming denotes food simmered in its juices or with little liquid. The pan is wrapped in aluminium foil or closed with a flour paste and water.

The main cooking appliances used for the methods described in this section will be presented below.

2.4 COOKING APPLIANCES

For thousands of years before the advent of the first cooking appliances in 1800, created by Benjamin Thompson, people cooked over open flames (BYRD & DUNN, 2021). Depending on materials and technologies at hand, various cultures have worked out a cooking surface heated by a fire below (KATZ & WEAVER, 2002).

More advanced early cultures, among them the Chinese Han Dynasty, used the ceramic *tsao*, a very early range in which the fire was enclosed. The late medieval period and the Renaissance brought many changes because of the greater use of iron. With the growth

of cities and consolidation of power, there was a trend toward elaborate cuisines and larger kitchens. Commercial establishments and wealthy or aristocratic households, having more means and more need, were the first to explore various types of stoves (KATZ & WEAVER, 2002).

During the 19th century and early 20th centuries, with the active participation of women in the labor force (KATZ & WEAVER, 2002), household stoves became popular (BYRD & DUNN, 2021). Cooks learned that instead of building a kitchen around a fire, it could be built around an appliance, like the brightly colored kitchen appliances (WILSON, 2013)

As of the '50s, several kitchen appliances facilitating the daily routine proliferated (KATZ & WEAVER, 2002). Flandrin & Montanari (1998) point out that the increasing number of devices that helped in domestic activities boosted the household appliance and processed food industries in the second half of the 20th century. The advance and mastery of technologies in the post-World War II period allowed the development of domestic artifacts such as refrigerators, freezers, microwave ovens, electric ovens, etc. (ROSENBERG, 1982). Food interaction in the face of these new technological opportunities transforms the concept of cooking (COLETTI, 2016).

Cooking appliances are categorized into major appliances: stoves, cooktops, electric ovens, microwave ovens and hoods. Small appliances include the most varied portable models such as toasters, air fryers, etc. As highlighted in the Research Scope subtopic (1.6), this study focuses on major cooking appliances, specifically gas ranges, which are mostly present in Brazilian households (IBGE, 2018).

Since its creation in the 19th century until the current days of the 21th century, the cookstove has experienced few structural changes in its format, being heir to the wood cookers built in cast iron (MARTINS, 2013).

By the mid-19th century in both Britain and the United States, the closed range or "kitchener" had become the only kitchen essential in middle-class kitchens (WILSON, 2013). The gas stove set a new standard for cooking appliances (HESKET, 1997). Norman Bel Guedes, in 1932, developed a technically simple model (Figure 2.10) providing better use of space for food storage, standardizing components that enabled the large-scale production of 16 different cooker models.

FIGURE 2.10 – Gas Stove by Norman Bel Guedes from 1932

SOURCE: CENTRE POMPIDOU, 2000.

The new "ranges" influenced cooking technology throughout the Western world. The rise of urbanization encouraged people to seek fresher foods. Baking, simmering, and frying became popular methods, which became possible after the introduction of home stoves (KATZ & WEAVER). Cooks benefited from flexible, waist-high cooking, less bending and lifting, less smoke, and no ash in the food. Their ovens reached and maintained desired temperatures in less time, allowing daily cooking and more flexible menus (KATZ & WEAVER, 2002).

The cooking appliances presented in this section provide an overview of three centuries of innovation. Despite continuous technological development in this field, few advances have been made on sustainable design. In Brazil the general characteristics of stoves follow similar pattern. Table 2.5 illustrates this reality, presenting some stove models produced by the Brazilian manufacturers in 2021 (members of ELETROS).

TABLE 2.4 – Portfolio Stoves offered by Brazilian Manufacturers in 2021 (ELETROS members)

MANUFACTURERS	BRANDS	COOKING PRODUCTS (STOVES)
ELECTROLUX	ELECTROLUX (1) CONTINENTAL (2)	
ATLAS	ATLAS (3) DAKO (4)	
ESMALTEC	ESMALTEC (5)	
ITATIAIA	ITATIAIA (6)	
MUELLER	MUELLER (7)	
WHIRLPOOL	BRASTEMP (8) CONSUL (9)	

SOURCE: (1) Electrolux. Available on: loja.electrolux.com.br. Accessed in October, 2021; (2) Continental. Available on: www.continentalbrasil.com.br. Accessed in October, 2021; (3) Atlas. Available on: www.atlas.ind.br. Accessed in October, 2021; (4) Dako. Available on: www.dako.com.br. Accessed in October, 2021; (5) Esmaltec. Available on: www.esmaltec.com.br. Accessed in October, 2021; (6) Itatiaia. Available on:

www.minhaitatiaia.com.br. Accessed in October, 2021. (7) Mueller. Available on: loja.mueller.ind.br. Accessed in October, 2021; (8) Brastemp. Available on: www.brastemp.com.br. Accessed in October, 2021; (9) Consul. Available on: www.consul.com.br. Accessed in October, 2021.

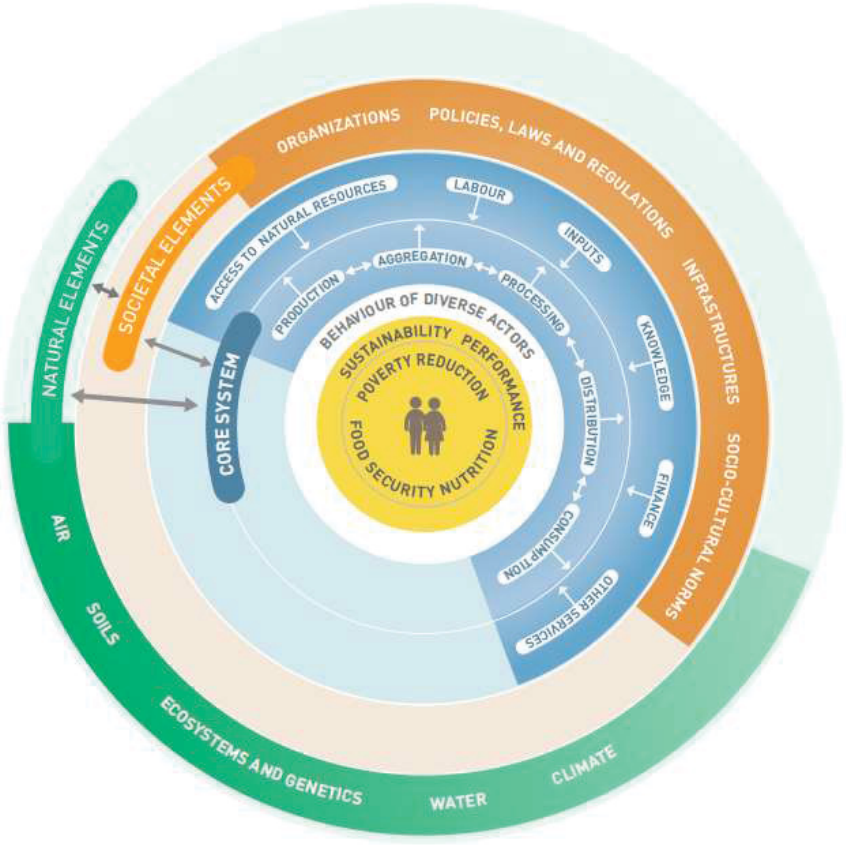
Worth mentioning that some home appliance companies working on sustainability issues focus only on approaches such as the Green Design and Ecodesign, disregarding the user and the effects generated in all sustainable dimensions.

The following topic will focus on the impacts of cooking practice and its implications for sustainability.

2.5 THE SUSTAINABLE DIMENSIONS OF SUSTAINABLE COOKING

Food systems encompass the full range of actors. Their value-added activities are interconnected and involve the production, aggregation, processing, distribution, consumption, and disposal (figure 2.11) of food products from agriculture, forestry, or fisheries and parts of the broader economic, social, and natural environments in which they are embedded (FAO, 2018).

FIGURE 2.11 - Food System Wheel



SOURCE: FAO (2014)

It is a complex system comprising subsystems such as the agricultural system, waste management system, input supply system, etc. The food chain interacts with other vital systems, such as energy, trade, and health. Thus, a structural change in the food system may come from a shift in another system; for example, a policy that promotes more biofuel in the energy system will significantly impact the food system (FAO, 2018).

The Food and Agriculture Organization of the United Nations (FAO) defines sustainable cooking as one of the final steps of the Sustainable Food System. The stage of cooking food is incorporated in the consumption stage (fig. 2.11) and involves socioeconomic and cultural aspects, nutrition, cooking methods, energy sources, and appliances that directly affect the dimensions of sustainability: environmental, social and economic, including public policies (FAO, 2014).

The cooking process consists of 4 steps that include food cleaning, separation and preparation, the use of cooking techniques, and refrigeration (FDA, 2022). Figure 2.12 illustrates the steps of the process, including the main focus of this research associated with step 3.

FIGURE 2.12: Cooking process steps

SOURCE: FDA (2017).

Among the most important pillars of sustainable cooking is the change in user behaviour towards a more rational use of resources. Another important pillar deals with the use of technologies to reduce water, gas and electricity consumption, conscious consumption of food, and improvement of preparation and reuse techniques (BRASIL, 2013).

The sustainable cooking habit implies environmental rationality that emerges from the potentialities and possibilities contained in different material processes, ontological orders,

and symbolic formations: ecological potentials, cultural meanings, technological developments, political strategies, and social changes (LEFF, 2006). These processes of building a sustainable society are mobilized by knowledge, in this case the activity of cooking and the principles of sustainability, constituted by actors responsible for social change and the transition for sustainability (DIAS, 2016). The impacts observed in the following topics contribute to broadening this knowledge which guides a sustainable society.

2.5.1 The Impacts of Cooking on the Environmental Dimension

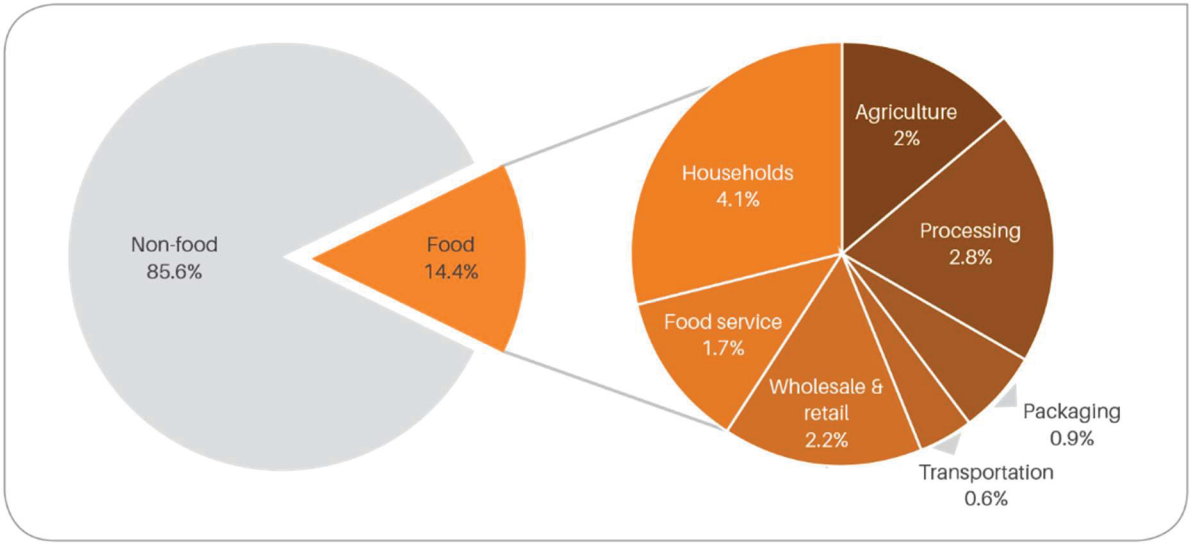
Food production is the largest source of global environmental change. Agriculture occupies about 40% of global land, and food systems are responsible for up to 30% of global greenhouse-gas emissions and 70% of freshwater use (EAT - LANCET, 2019).

Maréchal & Holzemer (2015) argue that the cook's experience, culture, resources, and goals directly impact energy and water consumption during cooking practice. Indeed, the environmental impacts caused by home cooking include the overuse of water, energy, ingredients, and contributions to the greenhouse effect, exacerbating the consequences of climate change (FAO, 2014).

Information regarding water consumption for typical processes in the kitchen, such as cooking, is even scarcer than energy information (RICHTER & STAMMINGER, 2012). A EUROSTAT (2007) report states that household water consumption to cook represents around 10% of residential consumption. Hager & Morawicki (2013) corroborate this information by describing a water consumption equivalent to 13% for the task of cooking.

In terms of energy consumption and associated impacts on natural resources by using oil, gas, charcoal, or electricity generated by dams, agriculture represents less than a quarter of the entire food cycle consumption, while the household cooking process leads the energy resource consumption, as shown in Figure 2.13.

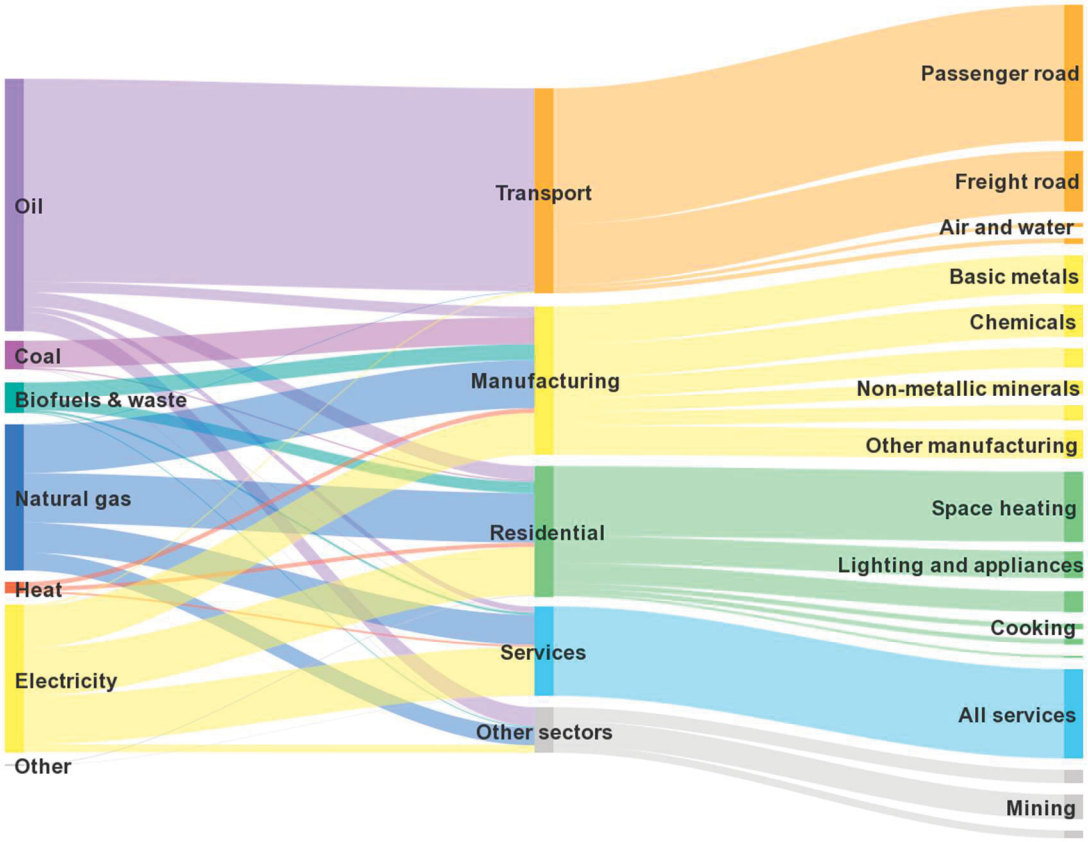
FIGURE 2.13: Energy consumption across Food System



SOURCE: CIAT (2017).

Concerning overall energy consumption worldwide, the household sector accounts for 21%. Hence, cooking represents the third largest consumption within the domestic environment, as shown in figure 2.14.

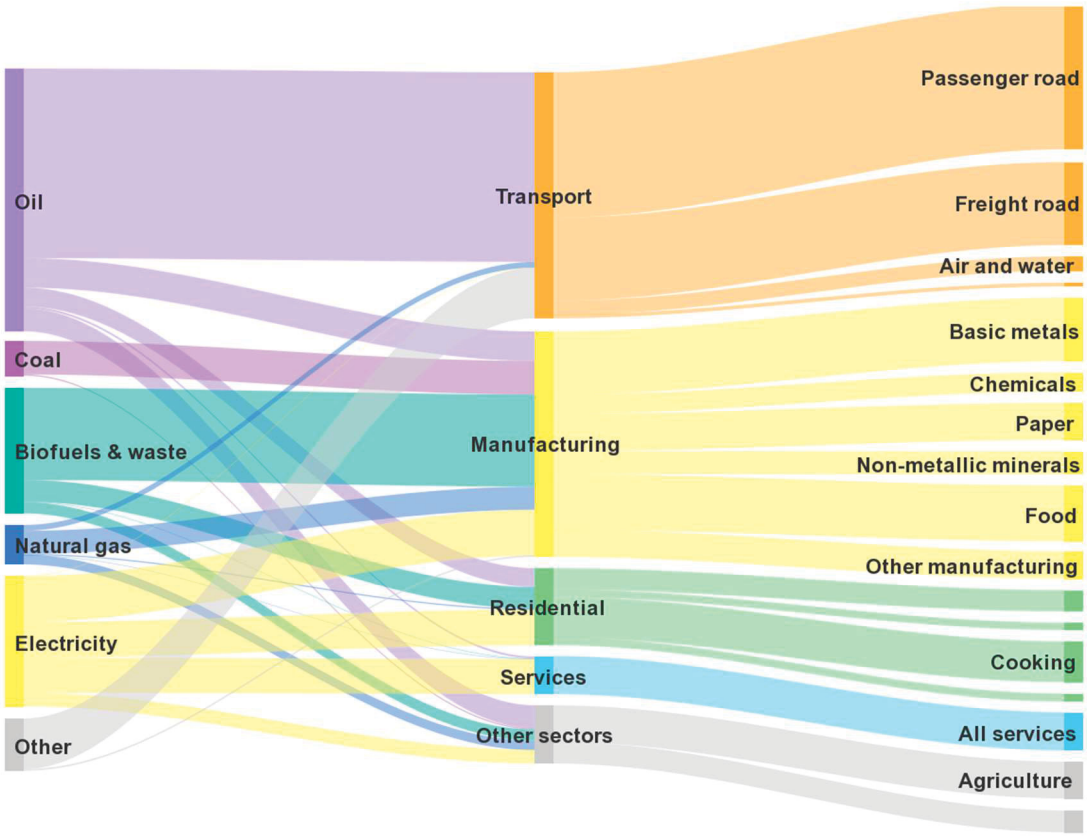
FIGURE 2.14 – Global energy consumption by sector in the year 2021



SOURCE: IEA (2022)

In Brazil, the process of cooking food corresponds to 52.64% of household energy consumption and it is equivalent to a significant 6.3% share of total Brazilian consumption (figure 2.15).

FIGURE 2.15 – Brazilian energy consumption by sector in the year 2021



SOURCE: IEA (2022)

Approximately 40% of the global population uses firewood or charcoal for cooking (MAES & VERBIST, 2012), resulting in severe environmental impacts with increased greenhouse gas emissions. Developing countries such as Brazil, Ecuador, and Indonesia, with high urban density and high commercial fuel subsidies, have drastically reduced traditional fuels such as firewood and charcoal (KAR & ZERRIFFI, 2018).

Meanwhile, Maes and Verbist (2012) point out that one of the cleanest sources of fuel for use in cooking is biogas, which is capable of emitting about 10% of the GHGs emitted by LPG stoves. The use of biogas also has the significant advantage of decreasing GHG emissions, as the methane fraction is burned and converted to CO2 (BALLARD-TREMMER & MATHEE, 2000). In addition, their plants produce excellent fertilizer as a byproduct (REN21, 2007; MKIRAMWENI & MSHORO, 2010).

The contribution of home cooking to climate change is rarely assessed due to the scarcity of data on cooking practices in the home environment (FRANKOWSKA et al., 2020). It is estimated that food is responsible for 37% of global GHG emissions (ROSENZWEIG et al., 2020). This estimate, however, encompasses only up to the retail/purchasing stages of the food supply chain, excluding the consumption stage, which can effectively contribute to reducing GHG emissions (FRANKOWSKA et al., 2020).

According to Frankowska et al. (2020), previous studies have indicated that GHG emissions from home cooking can be reduced by minimizing cooking times and appliance usage. Such a reduction can be as high as 86% in the case of pasta, for example (FRANKOWSKA et al., 2020).

Regarding popular cooking appliances, electric ovens are the least sustainable due to comparatively long cooking times and high energy demand, while microwaves have the lowest overall impact. Frankowska et al. (2020) report that pre-cooking some types of food would reduce the time required in the oven without substantially affecting sensory properties and significantly reducing GHG emissions.

The home cooking practice is crucial for increasing food safety and the quality of a substantial number of food products, yet individual home energy use varies considerably according to the preparation and mastery of cooking techniques (HAGER & MORAWICKI, 2013).

The impacts concerning issues related to the social sphere of sustainability will be addressed in the following topic.

2.5.2 Main Impacts of Cooking on the Social Dimension

The social dimension of sustainability considers human capital and seeks to promote a society with more social cohesion and equity, ensuring the rights of all (SANTOS et al, 2019). In this regard, home cooking incorporates a range of complex behaviors with multiple influences, encompassing a broad spectrum of practices (SHORT, 2003), being influenced by community factors and playing a role in determining norms and values in the community (WOLFSON et al., 2017). The choice of what to cook and how to cook is a political choice, as it can directly reinforce the social fabric at the local level. Pollan (2013) suggests that cooking not only gives people greater autonomy over the food they eat but is also the most critical

thing the average person can do to help reform the food system and make it healthier and more sustainable.

The principles of inclusion, justice, and democracy drive a socially sustainable society (SANTOS et al., 2019; KARUPPANNAN & SIVAM, 2011). In this sense, instrumentalizing actions that integrate marginalized individuals, value local culture, increase transparency on social issues, educate consumers on social dimension relevance, and promote social cohesion, contribute to a fairer and more sustainable society. Implementing more sustainable modes of production and consumption is more likely to succeed within a cohesive society that aims and works together for a sustainable future (SANTOS et al., 2019).

Some examples of integration related to cooking can provide accessibility and more autonomy to individuals with physical or mental limitations, in a safe way, in the use of appliances to prepare their meals.

Within the concept of equity, which deals with the fair distribution of services or resources according to the need of a group or individual (SANTOS et al., 2019), it is possible to educate and stimulate male reflection on their role in sharing tasks such as cooking at home. Women have predominantly performed this activity since the development of agriculture (BANERJEE-DUBE, 2016; GALLUP, 2021; MILLS et al., 2017; POLLAN, 2013; WRANGHAM, 2009).

Another impact that positively affects the social dimension of cooking concerns encouraging local cuisine, implying the valorization of local culture and stories that speak of being and belonging, pride, identity, and sociability (BANERJEE-DUBE, 2016). One of the ways of sharing these values and these stories consists of providing community or shared kitchens, which aim to ensure nutritional and social benefits, such as improving social cohesion, empowerment, and health promotion (ANTÔNIO & GUERRA, 2022).

In the home cooking context, healthier home eating habits can self-regulate appetite (WIT et al., 2015), influence the intake of more nutritious foods, and reduce fast food consumption (TOSATTI et al., 2017). In home-based adolescent food education, more sustainable home-cooked meals can contribute to forming healthier eating habits up to five years later (BURGESS- CHAMPOUX et al., 2009).

However, the COVID-19 pandemic revealed a trend toward increased obesity due to unsustainable eating habits within the home environment (SARDA et al., 2022). The potential significance of this trend could be associated with the lack of cooking skills, confidence and

more limited food choices (CHEN, LEE, CHANG, & WAHLQVIST, 2012; REES, HINDS, DICKSON, O'MARA-EVES, & THOMAS, 2012).

The ability and willingness to cook is one of the factors that can enable people to make informed decisions about their food choices, their diet, and their ability to follow healthy eating advice (CARAHER, LANG, DIXON, & CARR-HILL, 1999; HEA, 1998; LANG & CARAHER, 2001). Furthermore, any decline in cooking skills can leave people becoming more dependent on convenience foods, and while many are nutritionally well-balanced, others are more highly processed and often high in fat, sugar, and salt (STITT, JEPSON, PAULSON-BOX, & PRISK, 1996) and therefore require people to understand food labeling if they want to control their diet (GATLEY et al., 2014). Blythman (2013) believes that one should select unprocessed foods and cook them to eat safe and healthy food.

Strategies to encourage cooking in the home environment to improve the nutritional quality of food are gaining visibility. Many governmental and non-governmental organizations worldwide promote home cooking as a key-component of strategies to combat obesity and poor-quality diets (GATLEY et al., 2014), besides contributing to social cohesion within the household.

There is evidence of relationships between obesity and poor nutritional ingestion, consumption of convenience foods (LOBATO, COSTA, & SICHIERI, 2009), and consumption of out foods (BEYDOUN, POWELL, & WANG, 2009). There are indications of a range of potential diet- and obesity-related benefits derived from home food preparation, such as reducing the risk of obesity (KRAMER et al., 2012) and consuming a healthy dietary pattern (SIMMONS & CHAPMAN, 2012). However, these potential advantages have been mainly studied in specific socio demographic subgroups rather than on a larger population scale and have generally focused on the short term. Establishing the evidence base for home food preparation's health and social outcomes is crucial to inform the potential relative value of home cooking interventions (GATLEY et al., 2014).

In Brazil, guidelines for encouraging cooking practices are observed in official documents, such as the Marco de Referência de Educação Alimentar e Nutricional para políticas públicas (The referential framework of food and nutritional education for public policies.). Among other principles, it advocates the appreciation of cooking as an emancipatory practice and the preparation of one's food as a promoter of individual

autonomy and facilitator of the exercise of sensory, cognitive, and symbolic dimensions of food (MAZZONETTO et al., 2020).

Brazilians also have free access to the Food Guide for the Brazilian Population (2014), which aims to guide and encourage healthier eating behaviors. It recommends that the individual should prefer in natura or minimally processed foods and cooked preparations over ultra-processed foods (BRASIL, 2014). According to Mazzonetto et al. (2020), minimally processed foods are in natura foods that have undergone industrial processes but do not involve the addition of salt, sugar, oils, fats, or other substances. In contrast, ultra-processed foods are products submitted to several stages and processing techniques with many ingredients, such as salt, sugar, fats, and substances of exclusively industrial use (MAZZONETTO et al., 2020).

Another relevant point on the social dimension regarding cooking concerns food insecurity, a phenomenon that has been amplified by restrictions due to the pandemic of COVID-19. In fact, the pandemic has drastically shifted away the evolution towards the goals of the 2030 Agenda (UNEP, 2015). According to the SDG indicators assessment (UN, 2020), current estimates show that nearly 690 million people are hungry, or 8.9% of the world's population - an increase of 10 million people in one year and nearly 60 million in five years. If recent trends continue, the number of people affected by hunger will exceed 840 million by 2030 (UN, 2020). The World Food Program (UN, 2020) states that 135 million suffer from acute hunger largely due to war conflicts, climate change, and economic reverses. The COVID-19 pandemic has exacerbated those figures.

In this context, social policies could help to mitigate food insecurity. In Brazil, between 2002 and 2013, programmes such as *Fome Zero*, which encompassed strategies related to supply, food, health, education, and nutrition, reduced by 82% the undernourished Brazilian population (FAO, 2014).

Therefore, combined with social policies and socially sustainable behaviours, communicating social practices associated with using resources in food cooking can contribute to sustainability by increasing transparency.

2.5.3 The Impacts for Economical Dimension

The economic dimension of Design for Sustainability deals with the strategies that aim for a more equitable and fair society. It involves striving towards a more distributed economy, promoting valuing local skills and infrastructure, adoption of fair-trade practices, prioritizing network organizations, enabling transparency about the economic practices throughout the value chain and providing stimulus for local entrepreneurship. It presents a new economic paradigm guided by a dichotomy of values such as development instead of growth; small scale instead of large scape; cooperation instead of competition; distributed instead of centralized; well-being instead of consumerism; intangibility instead of tangibility; service-based; ethical instead of unethical; and sharing instead of ownership (SANTOS et al., 2019).

The decision taken in choosing ingredients and other resources for food preparation is intrinsically related to the economical dimension of sustainability and this is, also, a political choice set by the consumer. Seasonal foods, for example, are a more sustainable choice. They are locally produced, fresher, toxically safer, and cheaper (ANDRÉ, 2013). Choosing seasonal foods requires revisiting traditional receipts, valuing local producers, reviewing aesthetic paradigms regarding food ingredients and accepting the seasonality itself on food availability. André (2013) lists the following benefits imputed by the preterition to seasonal foods:

- **Lower price:** the products grown in season are available in larger quantities for sale in the various markets, which necessarily lowers their selling price, making them more economical when compared to those grown out of season. Besides the possible lower supply, out-of-season products have increased costs due to implementing more sophisticated agricultural techniques, complex logistics and/or intercontinental trade;
- **Better organoleptic characteristics:** out-of-season foods are usually harvested at an early stage of maturation to increase sales, even if this harms organoleptic characteristics such as color, texture, and flavor. On the other hand, seasonal foods tend to be harvested when they have reached their growth and maturation potential, giving them a more pronounced flavor and the characteristics expected by the consumer;
- **Optimized nutritional value:** all studies identified on the literature review found higher content of vitamins, minerals, and other essential and beneficial

> constituents in seasonal foods: in a study in Japan, it was found that the vitamin C content of spinach was reduced by 1/5 to 1/8 when it was grown out of season, and that of tomatoes and broccoli was reduced by up to ½. The carotene content was also reduced by ¼ in broccoli and by more than half in carrots grown out of season. In the same study, the vitamin C and carotene content were relatively stable in any season of production in some fruits and vegetables, such as kiwi, bell peppers and celery (FFTC, 2001). On the other hand, foods imported from distant locations must travel and be stored longer, increasing the loss of nutrients, especially vitamins.

The promotion of greater proximity between producers and consumers through commercializing food in fairs markets, and municipal places, is an example of successful public-private partnerships in the agricultural production and sales sector. In many countries where this practice has been increasing, such as the United States of America and European countries such as the UK and Sweden, benefiting producers and consumers while lowering production pressures, respecting the typical agricultural calendar of the species, and using less aggressive agricultural techniques for the environment (WILKINS, 1996; WILKINGS et al., 2000; LAPPING, 2004; ANDRÉ, 2013). In Brazil government initiatives have prioritized local farmers for supplying food ingredients to local schools, with a huge impact on enabling their economic viability.

Another impacting factor in the economic sphere is the appropriate choice of appliances and the energy source for cooking. Using LPG stoves adds advantages regarding cleaning, time efficiency, tree preservation, and usage ease. Nevertheless, in several countries, the high cost of the equipment and fuel, as well as challenges related to technical assistance, make its use unfeasible (IRIBAGIZA et al., 2020).

A study by IRIBAGIZA et al. (2020) indicates that users' perception of using LPG stoves exclusively is a major behavioral challenge with economic barriers because some dishes require more gas than people can afford. These individuals indicated that a complete abandonment of biomass stoves would require a continuous and timely supply of alternative sustainable fuel. No additional incentive would be needed if the economic barriers related to stove and fuel purchases were eliminated (IRIBAGIZA et al., 2020).

One of the initiatives aimed at reducing the cost of LPG and making it more affordable can be exemplified in The PayGas case, an LPG distribution company in South Africa. In 2021,

they developed a gas distribution system (figure 2.16) that allows customers to refill as much gas as they can afford safely and conveniently, thus lowering the entry point price for LPG cooking fuel.

FIGURE 2.16 – Paygas Case by Venture Catalyst Program, 2021.

SOURCE: CCA Annual Report, 2021.

The Venture Catalyst program of Clean Cooking Alliance (CCA), a non-profit organization, has teamed up with PayGas to build a new refueling station in Johannesburg's Soweto Township - the company's first station outside the greater Cape Town Area. CCA's supported PayGas in navigating issues such as site selection, planning, health and safety compliance, and government approvals. PayGas recorded over 3,000 transactions at the first station in 12 weeks. This success has led PayGas to extend agreements with LPG providers and expand the stations to serve all cities in South Africa over the next two years (CCA Report, 2021).

Economic progress, combined with more social equity and measures that protect and ensure environmental resilience, can benefit the business environment by reducing risks and being more attractive to investments (SANTOS et al., 2019).

Finally, Santos et al. (2019) reinforce that strengthening and valuing local resources; respecting and valuing local culture; promoting the local economy; promoting network organizations, which represent a link between people or organizations due to similar or complementary mutual interests; valuing waste reintegration and promoting education for the sustainable economy are fundamental principles for building an economically sustainable society.

2.6 DESIGN FOR SUSTAINABLE BEHAVIOUR APPLIED TO COOKING PRODUCTS

2.6.1 General Strategies

As explained earlier, the DfSB model that guides this research corresponds to the model drawn from the studies of Lilley (2007) and Tang & Bhamra (2008) at Loughborough University, UK. It was published in the paper "Design for Sustainable Behaviour: using products to change consumer behaviour", in 2011 by the Design Studies periodical. The Loughborough's model includes the axis elaborated by Lilley (2007), figure 2.17, that highlights the control level in making a more sustainable decision by users or products.

FIGURE 2.17 – Lilley's axis (2007)

SOURCE: The author (2022), adapted from Bhamra, Lilley & Tang (2011).

The control is directly influenced by adopting strategies that can ensure, guide or inform changes in user behaviors towards sustainability.

The studies of Tang (2010) and Tang & Bhamra (2008) analyzed behaviour models from socio psychological theories and listed seven strategies that enable design to influence behaviors and habits.

The strategies with a greater influence on the user decision-making are oriented to inform change (figure 2.16), considering that the user already has some knowledge about sustainability and can make choices that are better suited to generate lower impacts (BHAMRA et al., 2011).

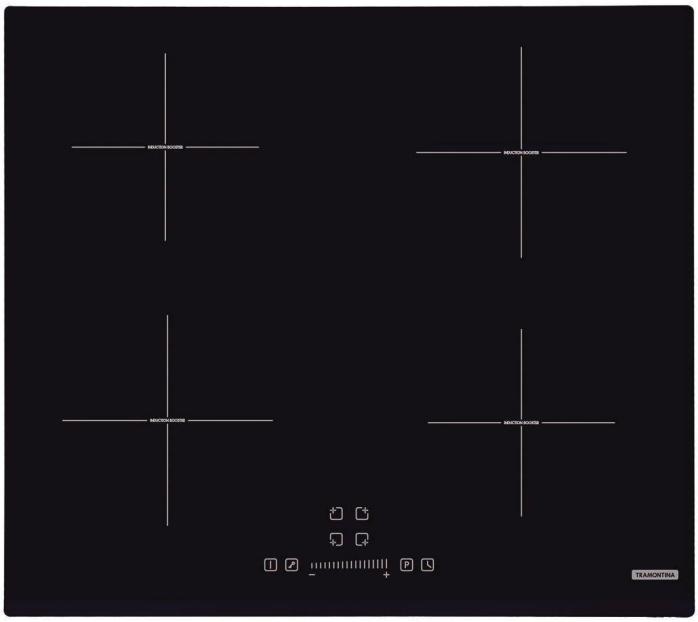
FIGURE 2.18 – Strategies to inform the change

SOURCE: The author (2022), adapted from Bhamra, Lilley & Tang (2011).

According to Bhamra et al. (2011), by adopting the Eco-information strategy, design proposes to educate the user by making consumption visible, understandable, and accessible to inspire consumers to reflect on the use of resource sources. It can express the consumption of resources such as water, energy, etc., and encourage the user to interact with the use of the resource.

Through a benchmarking study focused in good practices and gaps of household cooking-oriented solutions under the applications of DfSB strategy interventions, Hartmann et al. (2022) point to the induction cooktop from Tramontina (figure 2.19) as an example of Eco-information intervention.

FIGURE 2.19 – Tramontina induction cooktop



SOURCE: TRAMONTINA. Available on: https://www.tramontina.com.br/ . Accessed in March, 2022.

This product features electric resistances which do not conduct heat beyond the area marked on the ceramic glass table. After use, the display remains on, indicating that the surface is still hot, deactivating only when the temperature is below 30ºC. This product, on sale in the Brazilian market, makes cleaning easier due to the low surface temperature around

the heating areas. By changing the colour of the internal resistance of the cooktop from black to reddish tones, visually exposes the operation and energy consumption of the cooker in induction technology, characterizing the application of the Eco-information strategy.

Considering the Eco-choice intervention, design is oriented to empowerment, encouraging consumers to think about their user behaviour and to take responsibility for their actions. Users have a choice, and the product enables sustainable use (BHAMRA et al., 2011). Hartmann et al. (2022) highlight the Smeg oven (Figure 2.20) to illustrate an eco-choice solution.

FIGURE 2.20 – Smeg oven

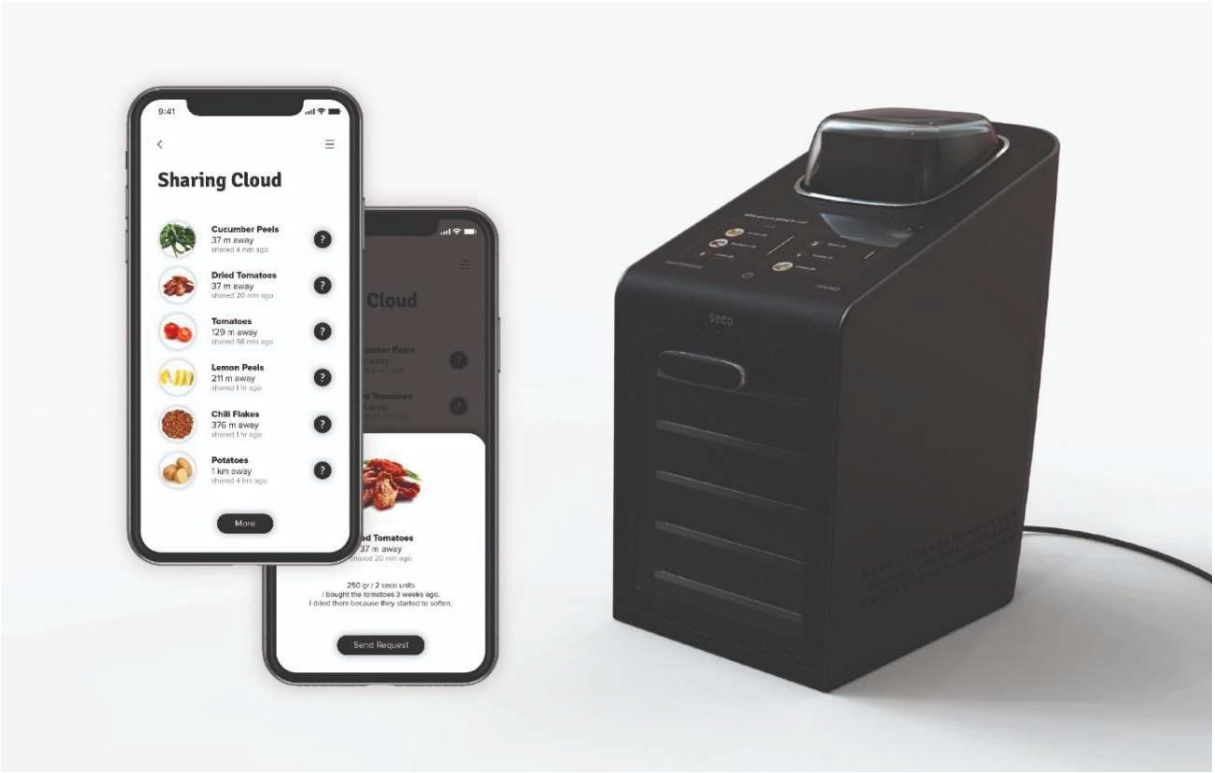
SOURCE: SMEG. Available on: https://www.smeg.com/ . Accessed in March, 2022.

It offers an energy-efficient ECO cooking function, Eco-function, which reduces energy expenditure but has a longer heating time. The other function offers the option of switching off the oven's interior light during cooking. Both provide energy-saving possibilities to the consumer by choice.

To inform users clearly about what they are doing and to facilitate consumers to make environmentally and socially responsible decisions by offering real-time feedback, the Eco-feedback strategy was carried out (BHAMRA et al., 2011). In this case, the artifact provides tangible aural, visual, or tactile signs as reminders to inform users of resource use. According to Hartmann et al. (2022), it is demonstrated by the conceptual design of the food dehydrator SECO (figure 2.21), which provides feedback to the consumer about the shelf life and

reusability of their food, informing them with direct data for better planning of use and less waste.

FIGURE 2.21 – SECO food dehydrator



SOURCE: GREEN PRODUCT AWARD. Available on: https://www.gp-award.com/en/produkte/seco . Accessed in March, 2022.

It aims to reduce food waste by creating an additional use possibility for certain parts of fruits and vegetables that are usually discarded. Together with its application, it tracks the food status, provides feedback and recommendations for use before expiration. It suggests the application of the Eco-feedback intervention.

Another strategy adopted by the product deals with Eco-spur, located in the intermediate zone of Lilley's axis (Figure 2.22) alongside the Eco-steer intervention, aiming to guide the change.

FIGURE 2.22 – Strategies to guide the change

SOURCE: The author (2022). Adapted from Bhamra, Lilley & Tang (2011).

The use of the Eco-spur approach inspires users to explore more sustainable usage by providing rewordings to 'prompt' good behaviour or penalties to 'punish' unsustainable usage (BHAMRA et al., 2011). The product could apply consequences to the user due to their actions through rewards or penalties. In the SECO dehydrator case, the integrated app promotes gamification by involving the exchange between a community close to the user, providing mutual benefits and avoiding waste.

Alternatively, to guide sustainable behaviours, Eco-steer allows the design to influence behaviour through affordances and constraints to facilitate users in adopting more environmentally or socially desirable habits through the prescriptions and/or constraints of use embedded in the product design (BHAMRA et al., 2011). The Smeg's induction cooktop (2.23) has the ECO-logic function, which characterizes an application of Eco-steer strategy.

FIGURE 2.23 – Smeg induction cooktop

SOURCE: SMEG. Available on: https://www.smeg.com/ . Accessed in March, 2022.

This cooktop restricts the power limit to 10 preset values from 1.5 kW to 7.2 kW of the appliance. It means saving on energy bills by setting the limit to using only what needs to be used. The Eco-Off function allows the zone to switch off before the timer sounds, making use of the residual heat and the Eco-heat function allows one of three residual heat indicators to continue cooking food or keep it warm. These applications incentives in inducing behaviour.

The level of interventions most influenced by the control of the product itself is to ensure change through the application of Eco-technical intervention and Clever Design strategies (figure 2.24).

FIGURE 2.24 – Strategies to ensure the change

SOURCE: The author (2022), adapted from Bhamra, Lilley & Tang (2011).

An Eco-technical intervention consists of a technical intervention to restrict existing usage habits and to automatically persuade or control user behaviour through design combined with advanced technology (BHAMRA et al., 2011). For example, the Winia's microwave oven (figure 2.25) includes the "Zero On" function that automatically turns off the appliance after 10 minutes without use to eliminate standby energy expenses. In this case, the product intervenes to ensure sustainable change, characterized by applying the Eco-technology strategy.

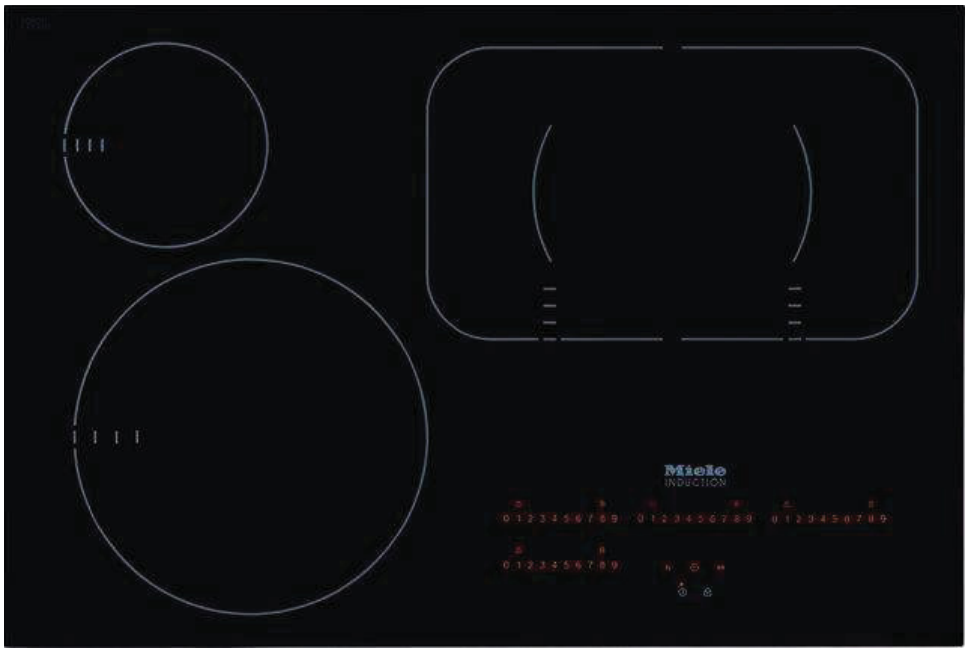
FIGURE 2.25 – Winia microwave

SOURCE: WINIA. Available on: https://winia-usa.com/ . Accessed in March, 2022.

Finally, the last intervention listed by Bhamra et al. (2011) deals with Clever Design which aims to automatically act environmentally or socially without raising awareness or

changing user behaviour purely through innovative product design. The Miele's induction cooktop applied such strategy (figure 2.26).

FIGURE 2.26 – Miele induction cooktop



SOURCE: MIELE. Available on: https://www.miele.com/en/com/index.htm . Accessed in March, 2022.

The model includes intelligent operation and safety features, activated only when it recognizes a pan on its surface, identifying its size and distributing the heat equally without dissipation; in addition, it protects against overheating. These functions automate processes and ensure more responsible use.

It is important to note that there is a lack of complete application of strategies in a single product. It represents an opportunity to be explored in the white goods market, given that one artifice strengthens the other and potentiates consumption behaviours focused on sustainability.

2.7 DISCUSSION

This chapter explores the topic of Design for Sustainable Behavior, the cooking habit, and cooking appliances.

State of the art in Design for Sustainable Behavior reveals the importance of the designer's role in influencing behaviors toward sustainability. Several authors such as Jackson (2005), Bhamra & Tang (2008), Vezzoli et al. (2018), Sampaio et al. (2018), and Santos et al.

(2018) explore perspectives that complement each other and combined, illustrate competencies needed from the professional to influence behavioral change.

Despite its potential for proposing solutions covering products, services, product-service systems and social innovation within the scope of the three pillars of sustainability, the theoretical basis in DfSB showed a large concentration of product-oriented solutions focusing mostly on the environmental dimension of sustainability. This is also exemplified by the goal of this research which focuses on the use of household appliances and resource consumption in cooking. However, despite the evident need for a better balance between the sustainability dimensions explored within the DfSB, it is important to note that even the broad application of the generalist concepts to physical artifacts requires a translation to the specific demands of sectors such as the home appliance industry, which is still quite incipient.

Several authors (WILSON et al, 2015; SHIN & BULL, 2019; LIDMAN & RESTRÖM, 2011; NIEDDERER et al., 2014) agree that although there is a growing number of studies investigating the application of DfSB strategies, there is a high scarcity of metrics and evidence to assess the effects of applied strategies on behavior change in the direction of sustainability. From the ethical perspective, all authors emphasize the designer's responsibility and obligation to act according to ethical principles.

Regarding cooking habits, it is relevant to point out that although cooking is a prehistoric activity with a well-defined meaning, it does not find a clear definition when investigated under the lens of sustainability. There seems to be a tendency of research to explore the theme of sustainable food from production to commercialization, disregarding the consumption stage that contemplates the cooking process, which is able to produce significant impacts on the environmental, social, and economic dimensions, as pointed out by the literature review.

It is also recognized that most studies involving cooking focus on energy consumption during product use. However, the activity requires the use of a significant amount of water in most common cooking methods. Another relevant factor not considered in the studies observed in the last decade is the contribution of greenhouse gas emissions from cooking to climate change, taking into account the high volume of daily meal preparation for individuals around the globe.

Concerning cultural habits, studies have shown a limitation in considering the benefits of these aspects, intrinsically related to the social and economic dimensions, corroborating

the greater focus of studies on environmental impacts. The Brazilian habits described in the chapter point to particular characteristics involving culture from different regions that can impact the successful solutions to disregard them and can be affected by propositions that aim for a global behavior pattern.

Considering cooking appliances, the evolution of products is a limitation in applying Design for Sustainability approaches in a general way. This gap is amplified when observed under the Design for Sustainable Behaviour lens, as solutions presented within the scope of cooking products.

Given this, it is important to highlight the relevance of translating DfSB and Sustainable Cooking concepts to instruct designers in developing products that empower changes toward sustainable behaviors through the application of DfSB strategies.

3 RESEARCH METHOD

This chapter describes the methodological strategy under which this research is structured to achieve the main objective: "**to propose Design for Sustainable Behavior guidelines to assist designers in developing home cooking appliances**", introduced in the first chapter of this dissertation (topic 1.3 on p. 21).

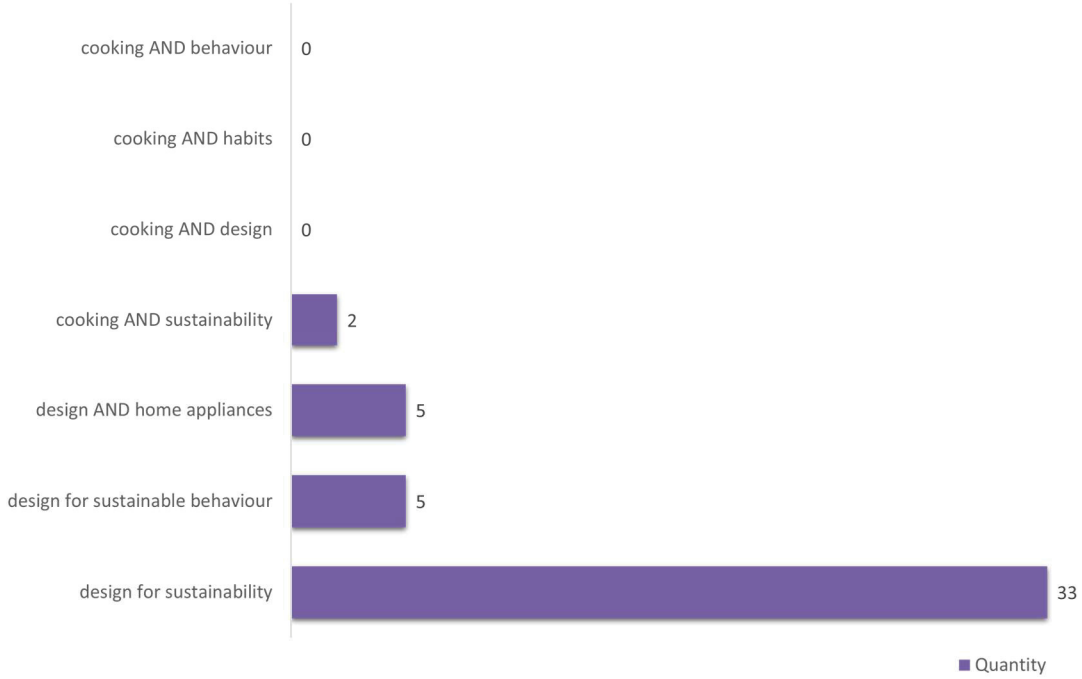
Initially, the nature of the research strategy is introduced along with the phases of research method used to implement this strategy. The data collection protocol as well as analytical strategy is then presented. The chapter concludes by presenting the approach to achieve validity, trustworthiness and ethical considerations.

3.1 CHARACTERIZING THE RESEARCH PROBLEM

Design research involves a systematic investigation aiming at the provision of knowledge or the development of configuration, composition, structure, purpose, value, and meaning to a given artifact (BAYAZIT, 2004; ARCHER, 1981). With such intent, Prodanov (2013) recommends that it must be methodical, critical, and planned. The planning depends on the problem's nature, state of the art, and the researcher's knowledge domain (PRODANOV, 2013). Hence, to characterize the research problem, a bibliometric approach was adopted in order to establish the state of the art of the theme.

Firstly, the search focused on the database “Brazilian Digital Library of Theses and Dissertations” (BDTD, 2021), covering the years 2011 to 2021. The main goal was to analyze the density of the content, evidence, gaps, and the evolution of Brazilian research associated with the theme of design and sustainable cooking. Such investigation, using the strings “design, cooking, sustainability and home appliances” has resulted on a low or almost non-existent volume of publications that intersect the area of design with the food cooking topic. The data mining was achieved from the specification of descriptors associated with the macro fields of this research: Design, Cooking, and Sustainability.

GRAPHIC 3.1 – Doctoral theses and master's dissertations in Design published in Brazil using the keywords Design, Cooking and Sustainability (from 2011 to 2021)



SOUCE: Brazilian Digital Library of Theses and Dissertations - BDTD (2021).

A total of 5 results using the descriptor "design for sustainable behavior" were found, highlighting:

- Forcato's (2014) dissertation on the application of the Eco-feedback strategy in a washing machine interface, developed at PPGDesign/UFPR;
- Garcia's (2019) dissertation on the characterization of the habit of taking a bath, also developed at PPGDesign/UFPR, and
- Lomba's (2020) dissertation on the diagnosis of the concept of transparency in digital services for more sustainable food consumption, also developed at PPGDesign/UFPR.

The investigation unveiled only two publications using the string cooking-sustainability strings. Only one of them, Gomes (2015), covers the design field, dealing with material selection and not finding convergence with the scope of the present research.

Five papers related to design and appliances were identified, most notably the dissertation by Neves (2011) describing the chronological experience of design in appliances; the thesis by Martins (2013) on the implications of appliances in transforming domestic routines in the kitchen, and the dissertation by Macedo (2014) exploring methods for evaluating user experience with appliances.

The analysis of these results indicated that the density of Brazilian research in the topic of this dissertation is quite limited. More specifically, the results highlight that in the Brazilian academic scenario, no thesis or dissertation have so far integrated the themes of Product Design, Consumption Behaviour, and Sustainable Cooking simultaneously, characterizing a knowledge gap worth to be investigated.

To enrich the data about the themes for the characterization of the problem, a Systematic Literature Review (SLR) was carried out. It aimed to identify "What are the emphases, gaps, and possible contradictions in the relationships among design, sustainability, user behavior, and home cooking?". The planning and protocol proposed by Kitchenham (2004) were used to perform searches, and the details of the results can be found in Appendix I.

In total, the systematic literature review resulted in a selection of 84 publications most relevant for the research theme. Among the vast collection of studies on food and cooking, many reflected anthropology and gastronomy viewpoints. The articles addressed the correlations between these areas, emphasizing a perspective focused on the whole food system. Few studies focused specifically on the aspects of cooking and its impacts on sustainability. However, since 2020, it has been possible to identify more health studies focusing on measuring impacts caused by household cooking.

Regarding the topic of Design for Sustainable Behaviour, there were a smaller number of publications focusing on cooking, although showing a growth of interest over the last decade. Most of the studies identified deal with generic and different models of strategies to shape behavior, and there were few references to the application outcomes that may indicate opportunities to improve the existing models. The number of publications in DfSB was even smaller in the service design area, pointing that has also knowledge gap.

Based on such results the conclusion is that the research problem dealt on this dissertation can be characterized as exploratory in its nature and such conclusion will be used as a central criteria for the selection of research method, as detailed on the next section.

3.2 SELECTION OF THE RESEARCH METHOD

The exploratory nature of the dissertation's problem pointed to a set of different possibilities in terms of research method choice. Design Science Research (DSR) was selected

as the main research method since the main goal of the research involves the proposition and assessment of an artifact. The intended artifact should assist designers in the development of cooking appliances capable of influencing sustainable behaviours.

The Design Science Research denotes a method that proposes an artifact to solve a problem category and evaluates its efficiency and effectiveness, employing abductive logic (SANTOS et al., 2018). It combines theory with practice, which is indicated when the study's objective consists to develop artifacts, and prescriptive solutions to generate knowledge to support problem-solving (DRESCH et al., 2015). According to Santos (2018), adopting this method involves reflecting on the feasibility and relevance of the proposed solution to other contexts with similar problem characteristics.

In this research, even though DSR is the main methodological orientation, comprising six macro steps, it is supported by other methods. According to Sein et al. (2011) and Dresch et al. (2015), depending on the purpose of the research, Design Science Research can foresee the joint use of other methods. The study uses Non-systematic Literature Review (Non-SLR) and Systematic Literature Review (SLR) as an additional research method, with the target of setting the theoretical framework that later will be used to analyze the field results. They also defined the DSR scope and supported the problem awareness step. This initial stage of the DSR also included the application of the Survey method, aiming to characterize the cooking appliances profile available in the Brazilian and international markets. Santos et al. (2019) reiterate that, besides enabling the researcher to profile a group of people, this method enables the analysis of a population of artifacts, services, or systems.

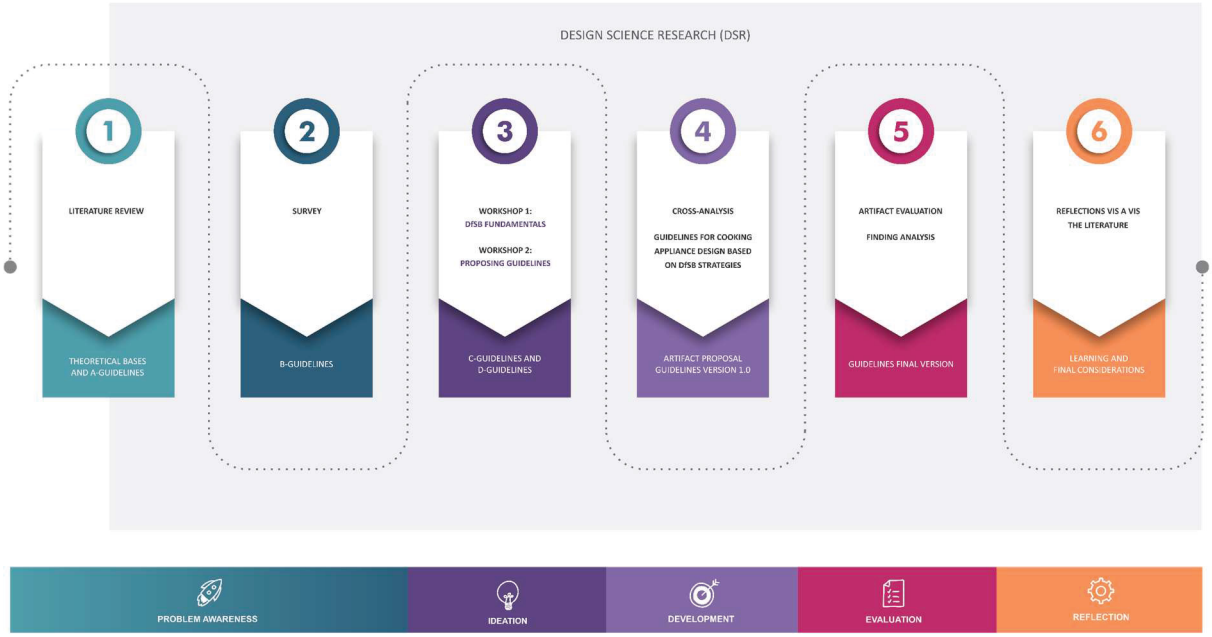
The Survey research method is appropriate for answering questions such as "What? How? Why?", in situations where the researcher has no control over the variables (PINSONNEAULT & KRAEMER, 1993). The purpose of this investigation, exploratory by nature, prioritized the study of contemporary phenomena, allowing the researcher to broaden her familiarity with the problem and the understanding of the state of the art of domestic cooking products.

Thus, the structure of the methodological strategy comprises (1) the literature review, (2) problem awareness, (3) ideation, (4) development, (5) evaluation, and (6) reflection, detailed in the next section.

3.3 RESEARCH STRATEGY OVERVIEW

The research strategy of this dissertation holds six stages, as presented in figure 3.1.

FIGURE 3.1 – Research Strategy Overview



SOURCE: The author (2023).

The first phase involved a literature review, which provided the theoretical framework and guided the Design Science Research (DSR) scope. The literature review allowed the revision of the main constructs, authors, and initiatives concerning the thematic of this dissertation. The findings from this review also resulted in the initial propositions for the guidelines proposed at the research outset (the **A - Guidelines**).

3.3.1 Phase 1 | Literature Review

The main research question of this dissertation (How can Design influence sustainable behaviours on cooking through home appliances?) guided both the non-systematic (N-SLR) as well as the systematic literature review (SLR). N-SLR's findings were based on expert referrals, LeNS network research, and studies produced over the last ten years by the Design & Sustainability Centre - NDS/UFPR. Furthermore, publications covering those derived by the PPGDesign/UFPR disciplines such as Design for Sustainability and Research Methods, were relevant to delineate the path of this research. The results obtained made it possible to define the main areas of study and delineate keywords that guided the Systematic Literature Review.

A SLR (Systematic Literature Review) was carried out to explore the thematic relationships between product design, sustainable behaviour, and food cooking (Appendix I). It has been guided by Kitchenham's model (2004), which involves six steps: planning, screening, eligibility criteria, quality and validation criteria, output and data export.

The first step, planning, involves identifying the question to be investigated, defining the goals, and database that will be the focus of research. The research question dealt with the impacts of cooking practice and the influence of design on sustainable cooking behaviours. Hence, the main objective of the SLR was to identify the state of the art, evidence, and gaps in Design, Sustainable Behaviour, and Cooking. The search platforms used were the Brazilian Digital Library of Theses and Dissertations (BDTD) and the Coordination for the Improvement of Higher Education Personnel (CAPES). The CAPES platform gives access to publications from worldwide databases, including Scopus, Dimensions, PubMed, Science Direct, Web of Science, Etc.

Therefore, the screening step describes keywords, strings, and boundaries. The searches were conducted by crossing keywords and strings from March to October, 2021. The limits were established by selecting 3 filters: filter 1 dealt with reading the title, keywords, and abstract; filter 2 selects the content by reading the introduction and conclusion; filter 3 consists of reading the entire publication.

The third step of the SLR establishes the search eligibility criteria, material inclusion, or exclusion. The inclusion criteria adopted open access research, peer review, English, Portuguese, or Spanish as a language, covering ten years (2011-2021). The following were excluded from the selection: 1. editorials, 2. notes, 3. letters, 4. comments, 5. case reports, 6. non-English, non-Portuguese and non-Spanish studies, 7. duplicates, 8. Abstract or full-text not available. The quality and validation criteria were addressed in the fourth step, and were carried out independently by two researchers, including the author of this dissertation. The validation of the field results came from crossing data obtained by both researchers. The final output step dealt with the final analysis, which resulted in the theoretical foundations of this project and will be reflected in the proposed guidelines.

3.3.2 Phase 2 | Survey

In order to also contribute to the problem understanding, a survey was developed in the second step. Its application focused on Design for Sustainable Behaviour (DfSB) strategies present in household cooking appliances, both at national and international levels, and allowed the establishment of the status of DfSB strategies praxis within the house appliances sector.

The comparative product, with descriptive logic, was carried out within the first phase of the DSR method, focused on understanding the problem. The survey protocol (Appendix III) was based on the McNair and Leibfried (1992) guidelines to evaluate solutions already available in the market and involved three stages: planning, data collection, and analysis.

The main goal of this method was to understand the state-of-practice regarding the application of DfSB strategies on products available in the Brazilian and global markets, within the sector of household appliances for cooking. It provided evidence of good practices as well as identifying gaps that might represent opportunities for innovation in the household appliance industry.

Considering the Brazilian market, the following selection criteria were adopted for product comparison: a) member companies of the Brazilian Association of Electrical and Electronic Manufacturers (ELETROS): Electrolux, Atlas, Esmaltec, Itatiaia, Mueller, and Whirpool. The data collection focused on the main e-commerce platforms.

At the international scope, the criteria for companies' selection are described below:

a) white goods, in the cooking category, made available on manufacturers' websites, marketplaces, or social networks of conceptual design projects;
b) products describing attributes with a potential to influence user behaviour regarding the environmental dimension of sustainability;
c) award-winning products in international design competitions such as the Red Dot Design Award (Berlin, Germany), IF Design Award (Berlin, Germany), Good Design Awards (Chicago, USA), A'Design Award & Competition (Como, Italy);
d) the biggest global trade fairs for home appliance product launches such as IFA Consumer Electronics Unlimited (Berlin, Germany), Eurocucina (Milan, Italy) and CES (Las Vegas, United States).

As criteria, it was considered at least one product for each DfSB strategy. The analysis used the "pattern-matching" approach (YIN, 2010) since the research aimed at finding literal replications of the DfSB strategies. According to Laville and Dionne (1999), pattern-matching consists of "associating the collected data with a theoretical model in order to compare them". This analysis has contributed to the second set of guidelines, the **B-Guidelines**.

3.3.3 Phase 3 | Ideation

3.3.3.1 Workshop 1

The third stage (ideation) involved the development of two collaborative workshops with the participation of the researcher and the Electrolux Latin American Design team, based in Curitiba, Brazil. The first creative workshop explored the implications of the DfSB for product innovation in a real-world industry context. It was addressed to all designers in the company, regardless of their design experience level.

The requirements for workshop 1's activity derived from the Literature Review on Design for Sustainable Behaviour (e.g., in topic 2.1, on p.33) and Cooking Habit (e.g., Topic 2.2, on p.46). The researcher presented the theoretical basis and cases to exemplify the application of DfSB strategies in products and services, providing a stimulus for the creative process.

The dynamic encouraged designers to apply DfSB strategies to cooking solutions, based on Loughborough's DfSB model. It considered the use of personas, DfSB strategy cards, and products from the Electrolux portfolio.

3.3.3.1.1 Characterizing Personas

The users considered in this work are part of the *Pesquisa Nacional por Amostra de Domicílio* (National Household Sample Survey) conducted by IBGE in 2019 and which addresses general characteristics of the residents, households, the types of fuel used in food preparation and the people responsible for the task of cooking according to gender, age, and level of education. Data obtained from the literature on cooking habits in Brazil were also used.

According to COOPER (1999), the persona describes a hypothetical user and his or her goals, representing the user throughout the design process. In this sense, this research protocol recommends using three personas with characteristics related to the objectives of the three levels of intervention of the model proposed by Bhamra, Lilley & Tang (2011).

Its elaboration required adopting the steps proposed by Kumar (2013), which aim to: (1) create a list of potential users based on data from consumer mapping, market research, etc.; (2) develop a list of user characteristics relevant to the project (demographic, psychographic and behavioral data); (3) define a number of potential users, depending on the purpose of the research; (4) create a persona for each user combining characteristics identified in step 2 and create a visual profile for each persona, allowing the visualization of their characteristics through a standard format.

In this study, the objective was to cover the main profiles observed in the Brazilian population related to cooking practices. The level of sustainability maturity of each persona was related to the intervention levels of the Loughborough model (BHAMRA et al., 2011) and the decision-making axis of Lilley (2009). As users became more aware of sustainability issues, they had more control over their decisions and were encouraged to reflect on their attitudes. In order to ensure behavioural change towards sustainability, lower involvement in sustainability actions implies more product control over decisions.

Thus, the participants of workshop 1 could propose solutions for a target persona based on the level of strategies better addressed to influence new habits in their routine.

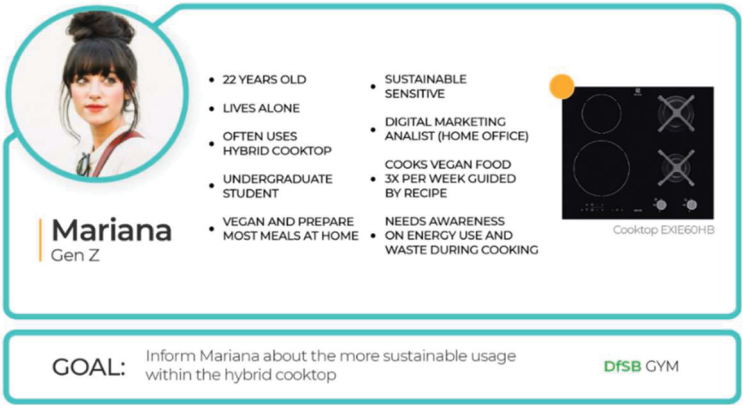
According to data obtained by IBGE (2019), the profile of people above 14 years old responsible for cooking in the domestic environment is mostly female, representing about 65.6% of the population. Therefore, all the personas presented below are female and responsible for domestic cooking.

Persona 01 | Mariana

To be part of this audience segment, the women selected to represent the persona Mariana (Figure 3.2) belong to the age group of 14 to 24 years, with an average of more than 12 years of study, and may be part of a family nucleus responsible for the family income or live alone. This group, corresponding to Generation Z, strongly appeals to more technological

products. They are identified with healthier food options and are more sensitive to issues related to sustainability.

FIGURE 3.2 – Persona 01



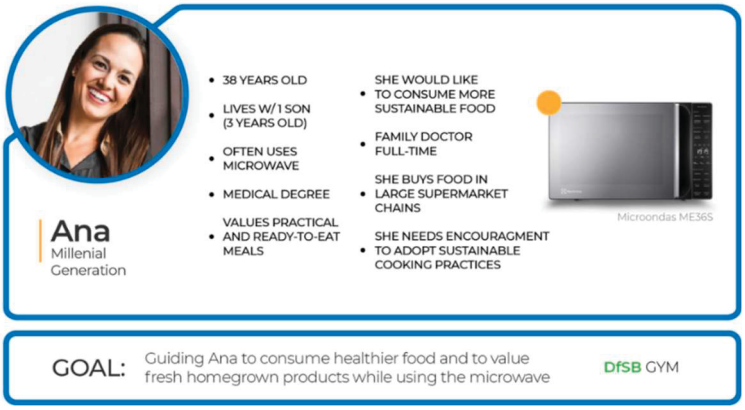
SOURCE: The author (2023).

It is intended to approach the profile with greater maturity on sustainability, more likely to be influenced by strategies that inform the user. In this sense, the objective established for the proposition of solutions sought to inform Mariana about the most sustainable use of the product, allowing greater reflection on consumption habits.

Persona 02 | Ana

The second persona (Figure 3.3) encompasses characteristics of women aged 25-49, representing 48.33% of the female population and with an average of 11.8 years of study (IBGE, 2019).

FIGURE 3.3 – Persona 02



SOURCE: The author (2023).

They may have an education level ranging from high school to university, an intense work routine, and an interest in healthier eating habits. This profile values products that offer practicality and agility in meal preparation.

Adopting this profile aimed at characteristics that can be directed by strategies that guide the user to desirable sustainable behaviors, sharing control in decision making. It allowed establishing the goal to develop solutions for these users.

Persona 03 | Roberta

Persona 3 (Figure 3.4) represents a group of women over 50 years old, with a lower level of education compared to the other profiles, with an average of 6.5 years of study. According to the characteristics of Brazilian households (IBGE, 2019), they usually live in households with more than 5 people, and their recipes are often based on family tradition with little appeal to more sustainable eating habits. This persona includes the largest number of people who use gas cookers for cooking.

FIGURE 3.4 – Persona 03

SOURCE: The author (2023).

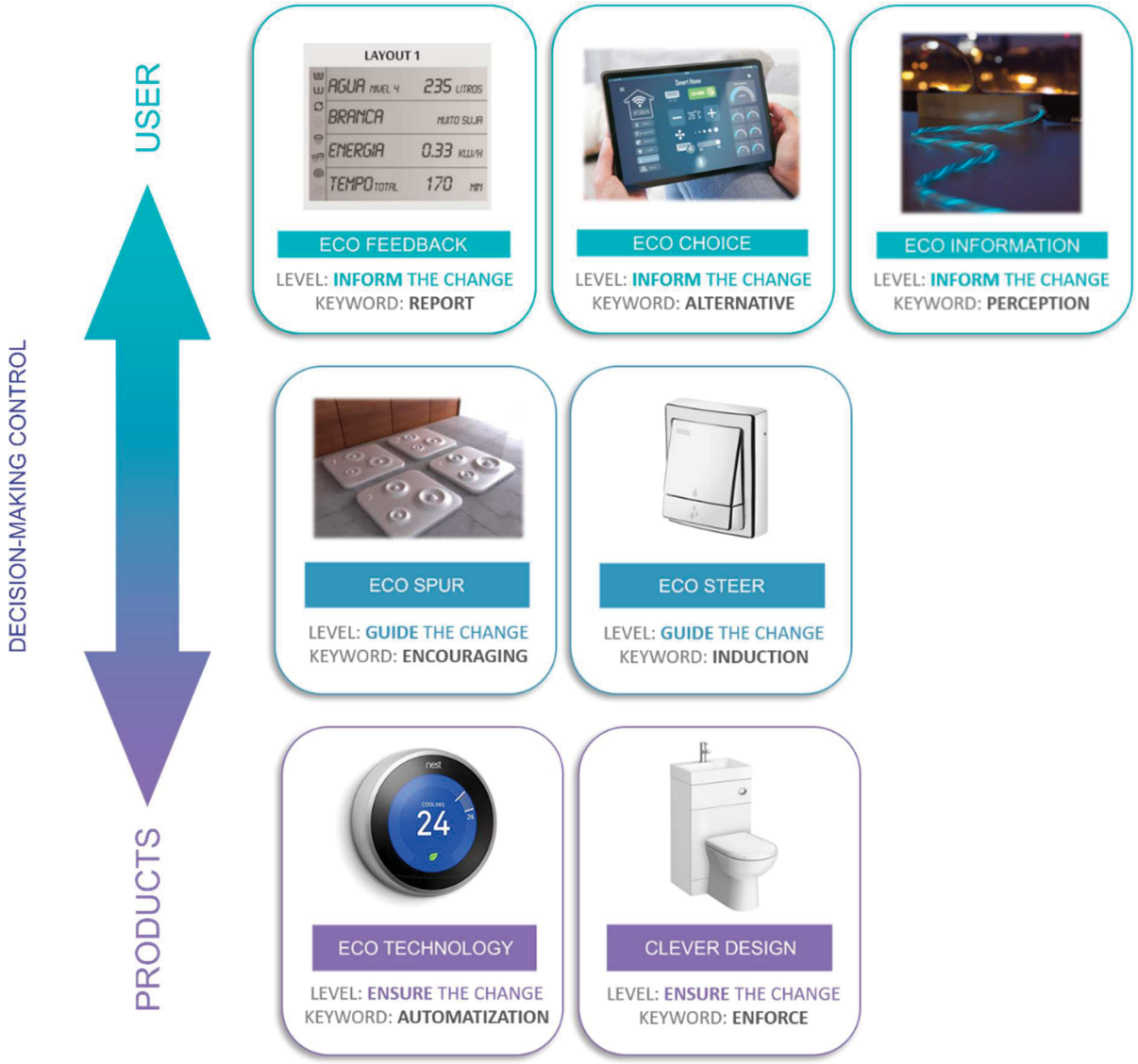
In this profile, it seeks to identify behaviours that need to be influenced by the product to ensure sustainable change occurs. The aim was to ensure the user would prepare a full meal while saving the main energy used.

3.3.3.1.2 DfSB strategy cards

DfSB strategy cards (Figure 3.5) were created from Bhamra, Lilley & Tang's (2011) model and used to represent the interventions individually, showing an example for each

strategy and carrying a keyword that reinforces its purpose. They were positioned close to the decision-making control axis proposed by Lilley (2009), and green, blue, and purple colour scales were adopted to aid the understanding of the relationship of the intervention levels with the control axis influenced by the user's decisions, the product's decisions, or both. Both axis and cards were positioned according to the persona profile and the maturity level about sustainability.

FIGURE 3.5 – DfSB Strategy cards



SOURCE: The author (2022), based on Loughborough's model (BHAMRA et al., 2011).

The workshop required 3 ideation rounds, and at the end of each round, the participants evaluated their colleagues' solutions. The voting process considered the innovation and feasibility level of proposals.

Due to the remote participation of some guests, the activity was conducted through a virtual visual collaboration platform, and the session was recorded, allowing the researcher to revisit the content. The result of the first workshop was a variety of solutions discussed and reflected upon with the group, generating insights and ideas for elaborating the C-guidelines.

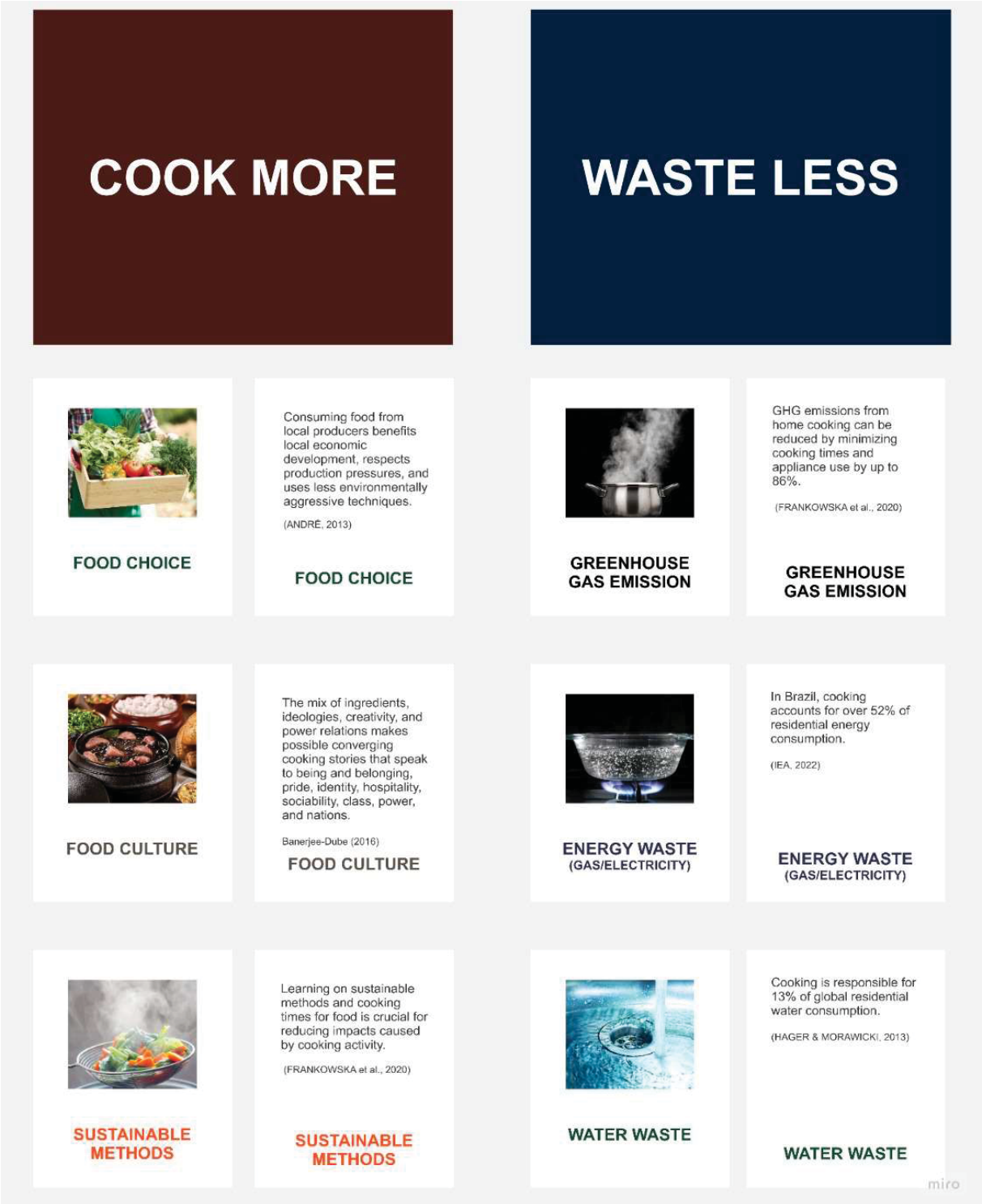
3.3.3.2 Workshop 2

The second workshop was held with a group of senior designers and managers involved directly with the development of cooking products. It consisted of a dynamic that demanded reflection by the professionals on the application of DfSB strategies, considering a product from the current Electrolux portfolio and design processes used. These reflections were implied in propositions to be interpreted by the researcher in order to further elaborate on the DfSB guidelines for the cooking appliances design.

The requirements for the development of this activity were based on the concepts of sustainable cooking and cooking habits that significantly impact sustainability. They were extracted from the theoretical basis and had the purpose of supporting the guests in identifying the existence of DfSB strategies in the product concerned, the maturity level of DfSB, gaps in the design process, recommendations, and their pros and cons for implementation.

This event was carried out only in a presential way with the use of physical boards, cards, and post-it for the idea's generation. The cooking habits cards were divided into categories that made it possible to divide the group of participants into two. They had the opportunity to explore 3 habits associated with consumption or cooking culture (Figure 4.13).

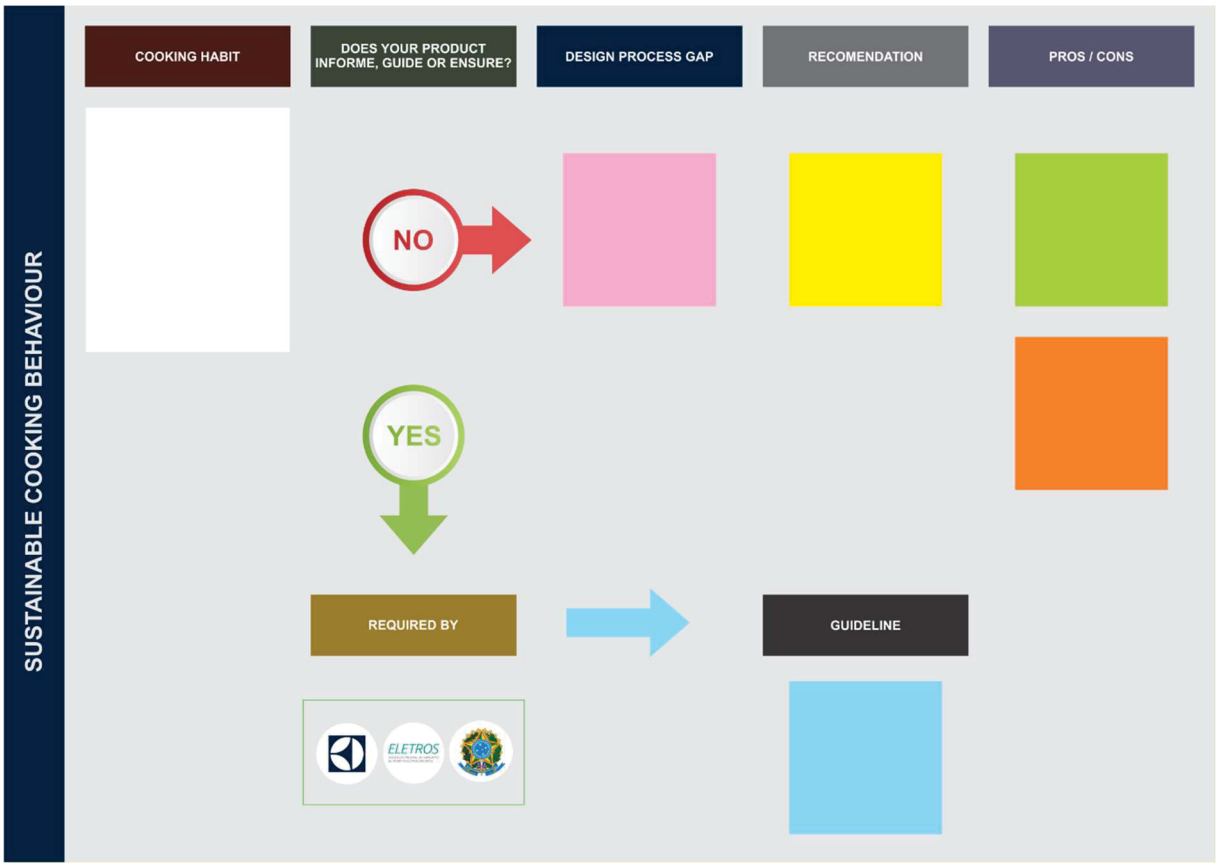
FIGURE 3.6 – Cooking habit cards



SOURCE: The author (2023).

Each group received a physical board that was used to collect the participants' notes. The participants were encouraged to discuss if the persona's product offered any DfSB strategy aimed at a sustainable change in accordance with the selected cooking habit. (Figure 4.14).

FIGURE 3.7 – Work board



SOURCE: The author (2023).

If the answer to this question was no, the participants were asked to identify the gap within the design process that should be filled and propose recommendations.

In case the product includes DfSB interventions, the participants should explain if it was required by the company, the industry sector, or the government through laws and regulations. This identification would make it feasible to bring attention to the company's procedures, evaluate its maturity level in terms of DFSB practices, and determine where it stands compared to other competitors. Additionally, it would be possible to comprehend the responsibilities imposed on manufacturers by governmental organizations and the sector's potential repercussions on sustainability. The blue board space therefore, included a description of the recognized guideline.

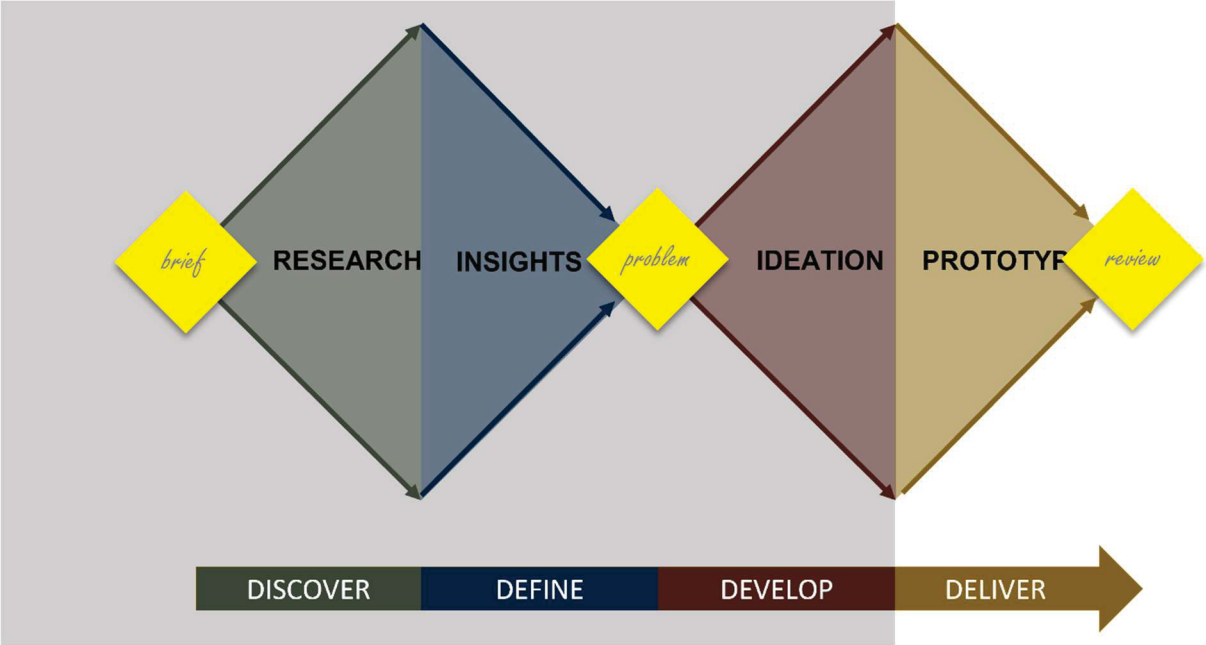
After conducting mirrored feedback, the other group provided comments in the green and orange spaces on the board, outlining the pros and cons of the proposal.

The findings from these workshops resulted in two sets of preliminary guidelines, **C-Guidelines** (workshop 1) and **D-Guidelines** (workshop 2).

3.3.4 Phase 4 | Development

The guidelines were further developed in the fourth phase of the DSR method. The preliminary guidelines, obtained through the researcher's interpretation on the theoretical basis and the results observed in the activities developed in the creative workshops, were synthetized in a checklist format, classified according to the phases of "discover", "define" and "develop" of the Double Diamond Design process (Figure 3.8).

FIGURE 3.8 – Double Diamond Process



SOURCE: The author (2023), adapted from the British Design Council (2019).

This design process was adopted in this study since most home appliance companies apply it (WALBER et al., 2017), as well as the partner company Electrolux.

A cross-analysis was performed, in a comparative and qualitative way, identifying similarities, particularities and gaps that resulted in version 1.0 of the guidelines.

3.3.5 Phase 5 | Evaluation

The first artifact version, proposed in the development phase, was discussed and analyzed by the design team and the Design and Sustainability managers in a virtual meeting, culminating in the fourth stage of the research strategy. The analysis parameters focused on the alignment with the practice of developing cooking products, the corresponding stage of the design process, the support for the designer's decision-making, instruction for new

designers, and contribution to the design team's learning. The evaluation occurred remotely through a collaborative visual platform that contained version 1.0 of the guidelines and space for assessment and suggestions. Afterward, the group discussed the designer's necessary competencies to influence behaviours. The contributions generated by the specialists' analysis made it necessary to adjust the prototype and also made it possible to validate the great majority of the proposals.

3.3.6 Phase 6 | Reflections

Finally, the last stage involved reflection, the researcher formalized the final version of the guidelines and the learning obtained with this study by communicating it to the academic and professional communities, highlighting the limits for innovation which transcend the learning.

This phase covered an analysis of the artifact's relevance for the sector, its potential for significant innovation from the application compared to the survey results, the designer's competencies to articulate these guidelines in practical situations considering climate change urgency, and, lastly, its contributions to the wider field of DfSB theory.

4 RESULTS & ANALYSIS

This chapter describes the results and analyses of the field research, based on the research strategy presented in the previous chapter (e.g., topic 3.3 on p. 88). It starts by presenting the findings of the literature review, and is followed by the presentation of the survey findings that complete the Design Science Research (DSR) phase of problem understanding. The literature review, and the survey results contributed to the preliminary set of guidelines, A and B, respectively. From this point, the results of the workshops included in the ideation stage are presented, which provided the basis for the development of Guidelines C and D. Finally, the evaluation results, the learning formalization, and the final version of the guidelines will be presented.

4.1 PHASE 1 | LITERATURE REVIEW

Chapter 1 and 2 present the contents derived from the Non-Systematic (N-SLR) and Systematic Literature Review (SLR), establishing the Theoretical Foundation for this MSc dissertation. The Literature Review made it possible to map studies related to this work and accurately identify gaps within this research's scope. It also achieved the first specific objective (e.g., Topic 1.3, p. 23), which deals with characterizing the Sustainable Cooking concept, its meaning in the Brazilian context, and general habits associated with more sustainable habits in this activity. Details about the SLR protocol can be found in Appendix I.

From the theoretical framework provided by the literature review, it was possible to establish the A-guidelines (Appendix II). Their content enables the identification of similarities, characteristics, and knowledge gaps that contributed to the final guidelines' proposal.

4.2 PHASE 2 | PROBLEM AWARENESS

4.2.1 Survey

The core question that guided the survey planning was "What DfSB strategies were applied into existing cooking appliances (stoves and cooktops)?". This survey aimed to highlight the best practices and gaps which could provide innovation opportunities for

companies in the household appliance sector. The survey protocol involved three steps described by McNair & Leibfried (1992), placed in Appendix III.

Initially, the first part of the investigation considered the Brazilian market context. In this sense, the companies selected are members of the Brazilian Association of Electrical and Electronic Manufacturers (ELETROS) such as Electrolux, Atlas, Esmaltec, Itatiaia, Mueller, and Whirlpool. The data collection covered the e-commerce shops of the ELETROS members, and each company's range of cookers and hobs for sale in Brazil was part of this sample.

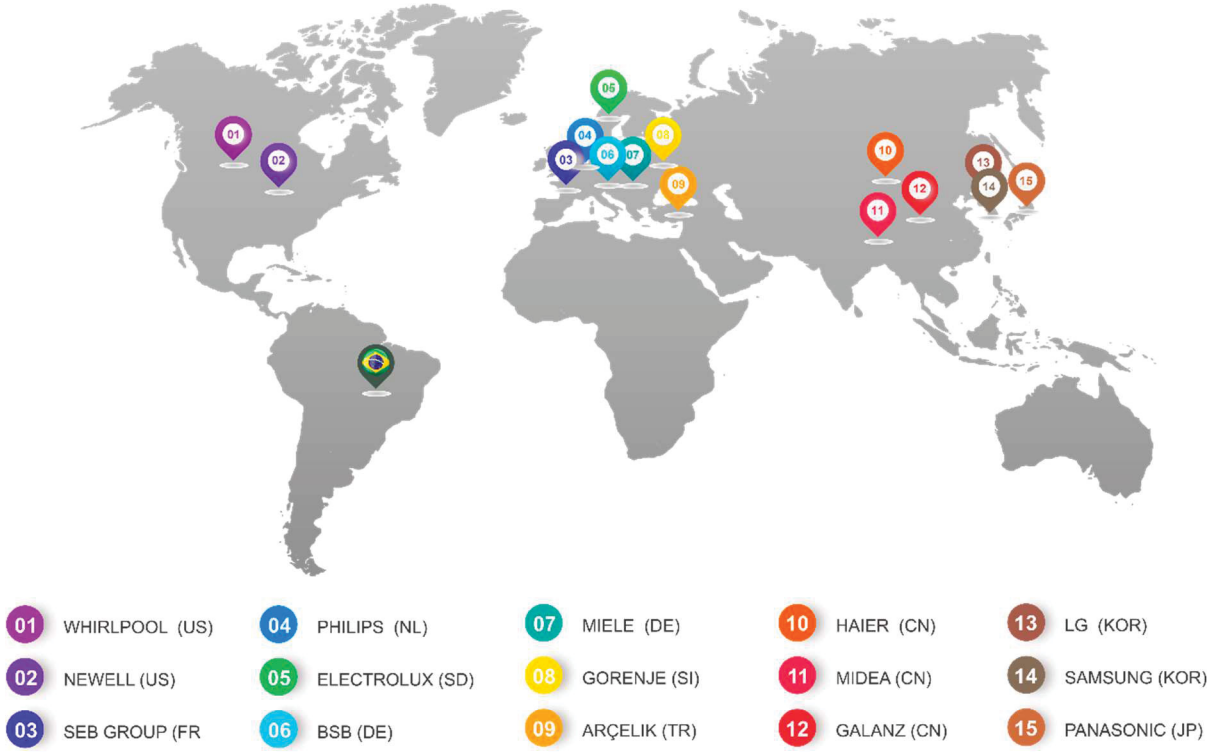
Among the 80 products analyzed, only induction cooktops models, manufactured by Electrolux, Mueller and Whirlpool, could be associated with DfSB strategies. These models have intelligent operation and safety features. The technology is activated when the pan is detected on the appliance's surface, distributing the heat efficiently. All models by these 3 manufacturers have overheating protection. These functions automate processes and ensure more responsible use, characterizing the application of clever design strategy.

Some instructions for user safety during use are included in the manuals, in accordance with the Brazilian norm NM60335-1 (ABNT, 2010), which deals with the safety of household appliances and similar products. However, no instructions aimed at influencing more sustainable behaviour were identified.

This lack of appliances in the Brazilian market capable of influencing sustainable cooking behaviour represents an innovation opportunity for companies and, at the same time, a window to enhance their relative competitiveness. Through DfSB these companies could position users as agents of sustainability, offer transparency in consumption data, encourage reflection on unsustainable behaviour and provoke more responsible choices.

For the second part of the survey a total of 15 international companies were selected, based on the criteria defined in chapter 3 (e.g., Topic 3.3.2, p. 90). These companies, located mainly in Europe and Asia (Figure 4.1), account for 66 cooking brands, which commercialized 278 major cooking appliance models worldwide.

FIGURE 4.1 – Global cooking appliance manufacturers



SOURCE: The author (2023).

From the global findings, there are five products which present at least one of DfSB strategy. The correlations between observed practices, strategies and intervention levels are all summarized on table 4.1.

TABLE 4.1 – Global product benchmarking | stoves & cooktops

PRODUCT	BRAND / MANUF.	SOLUTION	DfSB STRATEGIES	INTERVENTION LEVEL
 **P1 | Induction Cooktop**	JENNAIR / WHIRPOOL	Knobs and cooking zone are illuminated in reddish tones, visually indicating the product's function and energy consumption.	ECO-INFORMATION	INFORM
 **P2 | Gas Cooktop**	GAGGENAU / BSH	When in use, the activated knobs light up in reddish tones to visually indicate power consumption.	ECO-INFORMATION	INFORM

PRODUCT	BRAND / MANUF.	SOLUTION	DfSB STRATEGIES	INTERVENTION LEVEL
 **P3 | Induction Cooktop**	BEKO / ARÇELIK	Power management function: Allows users to manage and limit the total power consumed by the device, choosing from 5 levels.	ECO-CHOICE	INFORM
 **P4 | Gas Stove**	SAMSUNG	1) When in use, the activated knobs light up in reddish tones to visually indicate power consumption.	ECO-INFORMATION	INFORM
		2) SmartThings Cooking recommends personalized recipes based on preferences, shows what's on hand and tracks recipe search history.	ECO-CHOICE	
		3) Cook Smart: monitor the cooking activity in real-time. Energy usage alerts.	ECO-FEEDBACK	
		4) Smart Dial: it learns cooking behavior and preselects cooking modes, temperatures, and cook times used most often.	ECO-TECHNOLOGY	ENSURE
 **P5 | Induction Stove**	GE / HAIER	1) Guided cooking with a system that combines video-guided recipes from chefs with automatic time, temperature and cooking pace adjustments.	ECO-STEER	GUIDE
		2) Doesn't require preheating to bake, saving energy.	ECO-TECHNOLOGY	ENSURE

SOURCE: Jennair: www.jennair.com | Gaggenau: www.gaggenau.com/global | Beko: www.beko.com | Samsung: www.samsung.com | GE: www.geappliances.com. Accessed in June, 2022.

Again, the analysis of the results allows for the identification of some gaps, as well as opportunities for innovation. It is important to highlight the absence of integral applications of more than one DfSB strategy in a single product. Among the solutions evaluated, only two products presented the application of 2 up to 4 strategies from the total of Loughborough's

model (BHAMRA et al., 2011). Despite the assertion in much of the DfSB literature that the combination of strategies within interventions maximizes the adoption of more sustainable behaviours during use.

In the sample evaluated, the Eco-Information strategy was the most common strategy identified. This artifice is commonly adopted to encourage the user's perception of energy consumption. By keeping the products' operational logic unchanged, it can be implemented through extra resources, offering great potential for new behaviour adoption.

Another opportunity that could be useful for product development, which was explored only in P4, consists of personalized design for users. According to Tang & Bhamra (2012) understanding consumer habits is one of the resources that can help designers intervene on a behavioral level. Therefore, a personalized approach would increase users' identification with their actions' responsibility for the environmental impact. In the example (P4), such personalization and closeness with the user are given by the opportunity to inform the user which foods should be consumed and reused.

A positive point noticed was the presence of DfSB solutions directly on the product, ensuring a direct interaction of the user with the design for sustainability interventions, through the product interface. This dynamic exposes the sustainability actions of the manufacturers in a more intense and transparent way, helping to raise consumer awareness.

However, it is important to note that some applied interventions have contradictions, such as in induction cooktops (P1, and P2) which allow combinations of power of two burners in one. Despite this, the products lack transparency regarding consumption, which could be provided through eco-feedback, informing the actual expenditure of resources in each function, stimulating reflection and action from users when activating these functions.

Hence, in both comparative product analysis on this preliminary phase of the research, the results show a limited number of solutions actually actively targeting more sustainable behavioral changes. When they present such solutions, they do so at an inaccessible price for most of the Brazilian population, considering that 50.7% of them have family incomes up to 2,900 BRL (573 dollars) (IBGE, 2022). Nevertheless, the solutions identified can provide insights for new product development that influence user behavior in a more democratic way.

The results of this survey are presented in more detail in two publications carried out during the MSc course, one at the ISDRS 2022 congress (SCHERER et al., 2022) and another at

the journal Mix Sustentável (HARTMANN & SANTOS., 2022). These findings contributed to understanding further the problem, providing insights that enable the development of a new set of guidelines (B-guidelines), presented on Appendix IV.

Notice that the guidelines associated with the “discover” and “define” phases were obtained throughout the regular dialog with the industry partner during the analysis of survey results. Both A and B set of Guidelines provided the initial information that was employed on the ideation phase, as explained on the next section.

4.3 PHASE 3 | IDEATION

The purpose of the ideation phase was to co-create a set of guidelines on Design for Sustainable Behaviour, specifically designed for cooking devices on the white appliances sector. This co-creation was carried out with the Electrolux team, the industry partner of this research, which had an agreement with UFPR to expand the knowledge on Design for Sustainable Behaviour.

4.3.1 Workshop 1

4.3.1.1 Generating DfSB guidelines through product ideation

The first workshop aimed to explore the implications of DfSB in terms of product innovation in a real-world industrial context. The analysis made it possible to elaborate the C-guidelines. The partner company is based in Curitiba, and is a business unit of the Swedish multinational manufacturer for Latin America. The Electrolux Design team includes several professionals, from junior to senior levels, who work in areas such as Physicality in Design, Digital and Service Design, Communication in Design, and Design Strategy. Professionals from these areas work in different product categories, such as “food preparation”, which deals with cooking appliances.

The workshop took place on November 04, 2022, at Electrolux facilities in Curitiba. It lasted about two hours. Following the data collection protocol (Appendix V), professionals from all Design areas of the company were invited and 80 guests attended in a presential and remote environment.

The workshop started with an introduction of the researcher. This was followed by a presentation on behaviour and habit concepts and, subsequently, generic principles and domains of Design for Sustainable Behaviour (Figure 4.2). In addition, product and service cases were presented to illustrate the practical meaning of DfSB strategies.

FIGURE 4.2 – Workshop 1 | DfSB presentation at Electrolux, Curitiba, Brazil

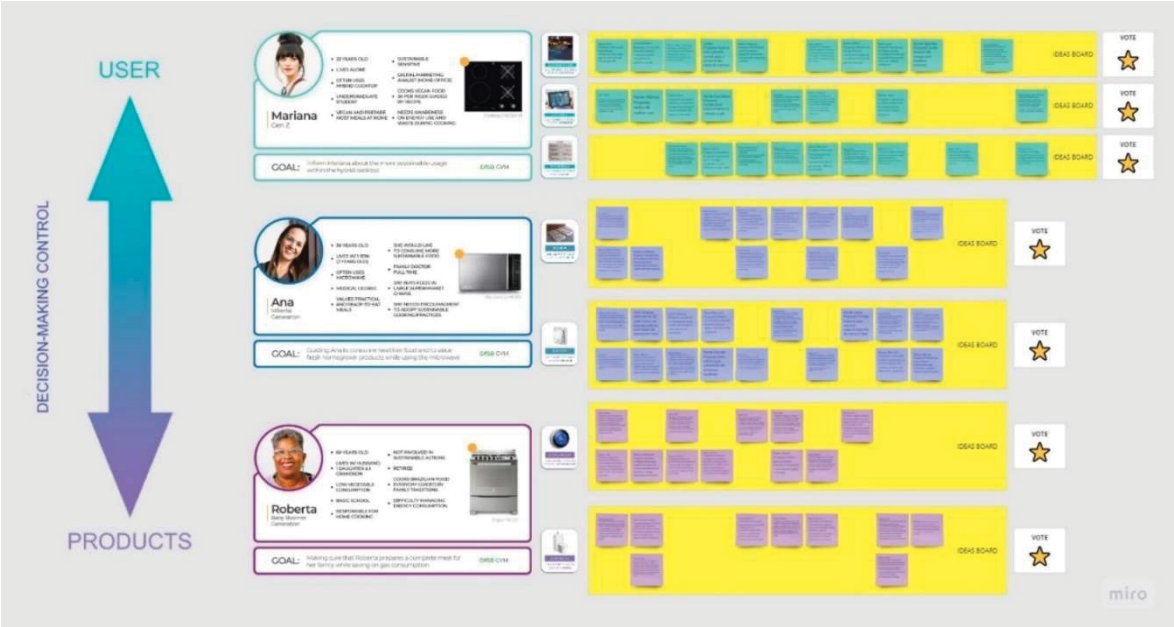
SOURCE: The author (2022).

The presentation held approximately 30 minutes and preceded the ideation activity. Guests in a remote environment could join the event via a Microsoft Teams link, with the support of Daniela Hartmann and Felipe Westphalen, both NDS/UFPR undergraduate research members who collaborated with this study.

The ideation activity consisted fundamentally of inviting the attendees to propose solutions for cooking appliances based on the DfSB generic strategies. The proposed solutions would later be analyzed in order to identify the underlying guideline, through a process similar to a grounded theory approach, building a plausible explanation about the Designer intent.

Considering the activity's development, named DfSB Gym, attendees were oriented about the workshop's purpose and how proposals should be elaborated, and it was carried out via a digital collaborative platform (Miro), allowing all guests, in person and remotely, to join in, as illustrated on Figure 4.3.

FIGURE 4.3 – Workshop 1 | DfSB Gym



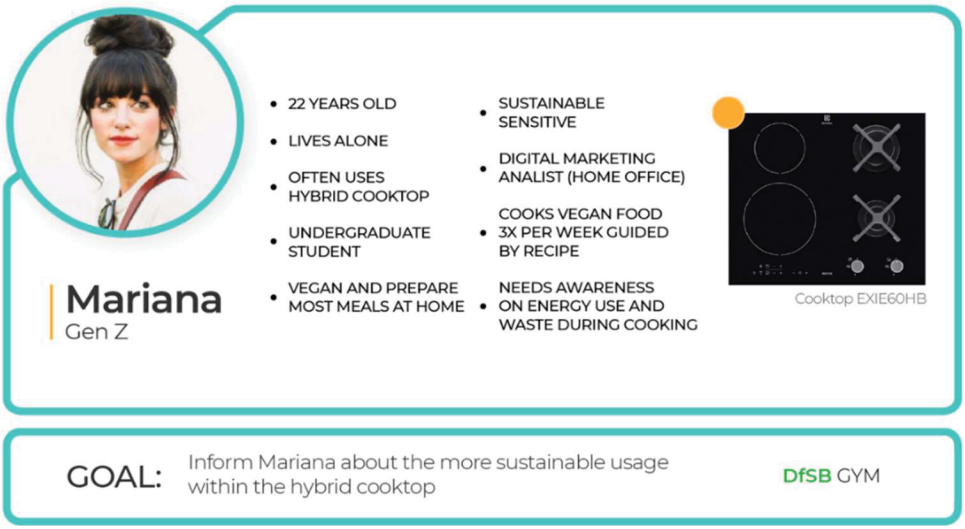
SOURCE: The author (2023). Access link: https://miro.com/app/board/uXjVPIFO-gs=/

The activity required 3 rounds each taking 10 minutes, including 8 minutes for idea generation and 2 minutes for voting on the most creative ideas that could be developed.

The researcher of this dissertation translated all ideas generated from the original language, Portuguese, to English in order to provide reader comprehension.

For the first round, the participants were instructed to propose 1 solution, choosing one of the available strategies for the proposed persona Mariana (Figure 4.4), presented alongside of the required DfSB generic strategy. The protocol for developing personas is described on Chapter 3 (e.g., topic 3.3.3.1.1, on p. 91).

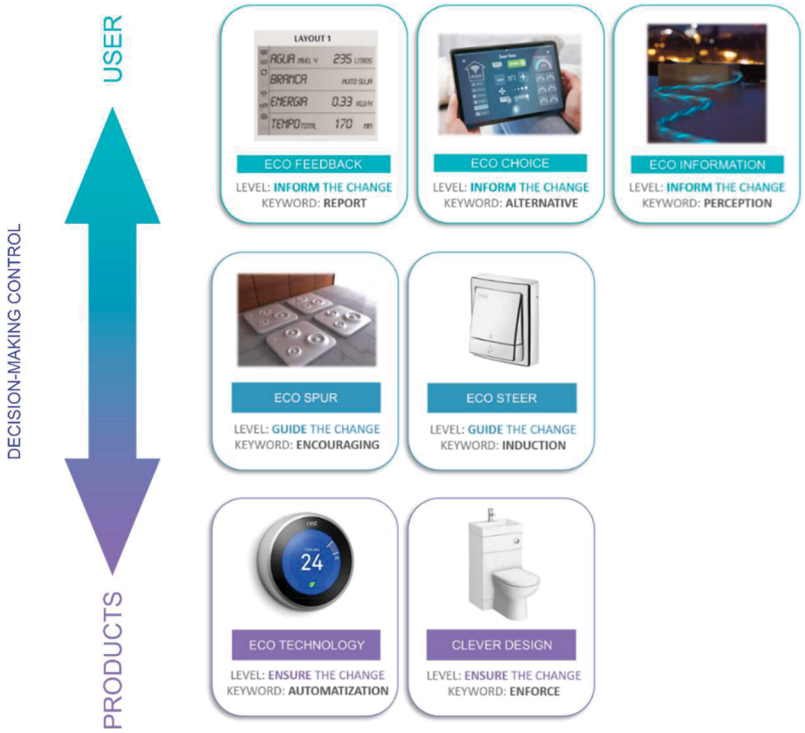
FIGURE 4.4 – Persona | Mariana



SOURCE: The author (2023).

The attendees described their ideas on post-its® placed in the yellow box on the right side of the DfSB strategies cards (Figure 4.5). These cards provided examples already presented on the opening presentation of the workshop. They exemplify the DfSB strategies and provided keywords to make it easier for the guests to remember the main focus of each strategy.

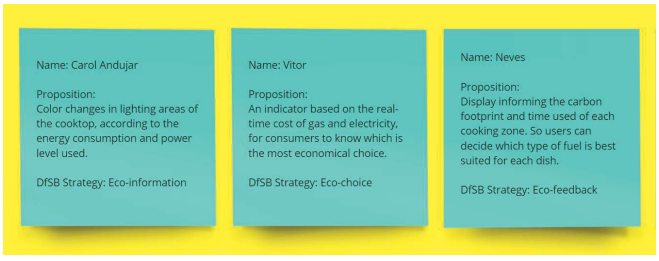
FIGURE 4.5 – DfSB Strategy cards



SOURCE: The author (2022), based on Loughborough's model (BHAMRA et al., 2011).

The selection of the most innovative and feasible idea associated with the correspondent DfSB strategy was carried out through a star emoji. The creators of the chosen solutions presented their propositions, followed by a group discussion to confirm its alignment or fit with the chosen DfSB strategy. Figure 4.6 shows the most voted ideas generated in the first round, that consider the group of DfSB generic strategies aiming to inform the change.

FIGURE 4.6 – Round 1 | The most voted propositions



SOURCE: The author (2023).

Applying the Eco-information strategy to Mariana's hybrid cooktop, the proposal with more votes suggested changing the user's cooktop lighting colours according to energy consumption and power level. In this case, the solution provokes the user to reflect on her consumption. However, a discussion with the group highlighted that due to the energy consumption required by LEDs, it may not be appropriate to illuminate all product areas but to trigger the user's perception towards a point with greater interaction. Being a solution that involves only delimitation of zones and LED application, the designers concluded that it does not meet technological and manufacturing barriers for implementation.

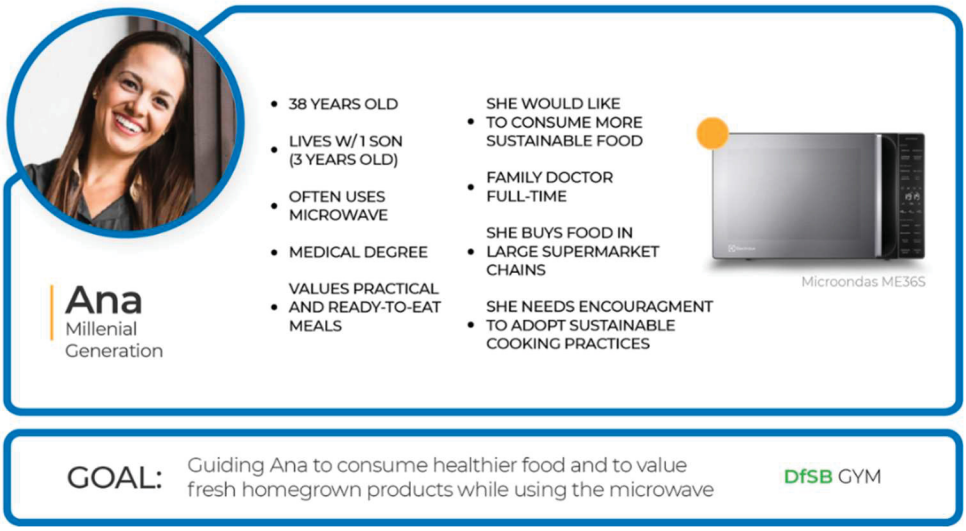
To represent the Eco-choice strategy, the participants selected an indicator proposition, which aims to help the user to reflect on the responsibility of her actions. It is positioned on the control panel, based on the real-time cost of gas and electricity for consumers choosing the most economical fuel. An aspect brought out in the discussion was the importance of understanding that cheaper solutions are not always more sustainable. The use of a cheap energy source is controversial as it can lead to longer preparation time and higher consumption of energy during cooking. Therefore, the discussion allowed professionals to comprehend that Eco-choice strategy was not adequately applied here. Financial benefits, whether to the consumer or the company, should not override the environmental and socio-economic benefits of sustainable change, the core of DfSB strategies.

Guided by the eco-feedback strategy, the proposition of a display on the control panel to inform the carbon footprint and the usage time of each zone was the one that received the majority of votes by the group. It is in line with the actual meaning of the eco-feedback strategy, informing users about the environmental impacts during the usage phase, allowing them to reflect on their decisions. A positive point perceived in this proposition is that information on carbon footprint can contribute to providing data capable of measuring in real time the actual impact that greenhouse gases emitted during the cooking activity and, thus, its impact on climate change.

The first-round conclusion pointed out that Eco-information and Eco-feedback propositions meet the goal defined for the persona Mariana, aiming to inform the user on more sustainable behaviours when using a hybrid cooktop (gas and induction) and associating DfSB strategies can enhance desirable behaviours.

The second round followed the same instructions of the first round but it now focused on persona Ana (Figure 4.7), with the habits that require the application of eco-spur and eco-steer DfSB strategies, aiming at guiding to more sustainable behaviour.

FIGURE 4.7 – Persona | Ana



SOURCE: The author (2023).

At the end of the creative round, the attendees voted on the most innovative and feasible ideas for this intervention level, as shown in Figure 4.8.

FIGURE 4.8 – Round 2 | The most voted propositions

SOURCE: The author (2023).

The Eco-spur proposition selected uses gamification as a resource. It is possible to map usage behavior through an application connected to the microwave oven. In this way, good practices carried out by users can be rewarded by unlocking more product functions, making the artifact more complete, and encouraging a change in habits. The group concluded that it matches the Eco-spur strategy application, sharing the control of decisions with the user. In this case, it is important to inform users in high transparent manner about the product's performance, thus avoiding frustration due to not being able to access all functions. That could result on a rebound effect on user behaviour, including product sabotage or even repulse the product (and the brand).

Considering the Eco-steer strategy there was a tie among 3 most voted for proposals. Thus, they were presented and discussed with the attendees. One of the solutions suggested offering the user a subscription to a "meal kit" containing different portion sizes for adults and children. This healthy meal would be prepared with ingredients produced by local producers and the adults' example could influence children's more sustainable behaviour, influencing their future decisions. Studies by Mills et al. (2017), Sliwa et al. (2015), Smith et al. (2010) and Wang et al (2014) point out that users with restrictions on time or working longer hours cook less frequently and usually prefer quicker preparations. However, users cohabiting with partners or children were more likely to prepare food at home (Blake et al., 2011; Virudachalam et al., 2014). Therefore, the suggested idea meets the user's needs, presenting the possibility of encouraging her to adopt more sustainable behaviour while using the microwave, with the potential to influence other cohabitants' behaviour.

Another Eco-steer solution consisted on indicating through the product interface how many years of life consumers would have “saved” each time they use pre-ready meal options. In the discussion, the participants comprehended that the idea seeks to induce the consumer to healthier eating habits, which benefits sustainable behaviors. However, it's clear that designers need to understand what sustainable food and sustainable cooking are, in order to properly induce the consumer to more sustainable habits. Another important aspect to explore is to test the user's reactions to rewards and penalties to identify which resource can be more effective in stimulating change.

To finalize the discussion on the Eco-steer strategy, the group analyzed a proposition that recommended the indication of the correct meal portions for each person, considering the user's weight and height, avoiding the waste produced by heating unnecessary amounts of food. Although waste is related to another stage of the consumption phase in the sustainable food system, the suggested way of preparation could reduce this impact and help, in a clear way, the user's reflection on waste.

All proposals elaborated in this round encourage a pro-active adoption of more sustainable behaviours by users through encouragement such as gamification, prizes, punishments, and directions. Hence, there was a higher expectation regarding the possible consumption impact of the proposed solutions, although the user's actual behaviour was still an uncontrolled variable.

Finallly, on the last round, attendees focused on propositions for the persona Roberta (Figure 4.9), targeting to ensure gas consumption reduction while the consumer uses her stove to cook.

FIGURE 4.9 – Persona | Roberta

SOURCE: The author (2023).

At this workshop stage, the attendees should adopt eco-technology and clever design strategies in order to ensure that desirable behaviour change. At its conclusion, the group selected ideas by individual vote, as it was carried out on the previous rounds. On these stage 2 solutions were selected for each DfSB strategy (figure 4.10).

FIGURE 4.10 – Round 3 | The most voted propositions

SOURCE: The author (2023).

In terms of the eco-technology DfSB strategy, one of the concepts properly applied the strategy by addressing the possibility of the user to choose what type of food to prepare. The product would automatically control time and temperature through sensors, both in the oven and on the top burners, consuming only the strictly necessary fuel.

The second concept suggested that the product should ensure that all recipes are ready in similar timeframes, avoiding having to reheat food, taking into consideration the fact that the user creates multiple dishes. This proposal satisfies the requirements of the eco-

technology strategy by ensuring change. However, one aspect, the longer preparation time for particular dishes, brings attention to this alternative. The simultaneous completion of all recipes may result in certain dishes taking longer to prepare than others. In this way, gas consumption would increase, which would have an adverse effect on sustainability. Cooking experiments and more research would be required to determine whether the solution's advantages are effectively sustainable and discourage undesirable behavior or other unforeseen side effects.

The ideas generated in association with the Clever Design strategy presented some conceptual divergence among the attendees. One of the suggestions involved using the area of the cooker structure under the oven as a drawer to keep the meals warm while the others are prepared, avoiding the need to reheat food. The first aspect of this concept that needs to be emphasized is that the user keeps control over her choice to use or not the warm drawer. Therefore, the product does not take responsibility for actually ensuring the change. This proposal uses in fact the Eco-steer approach, which encourages users to do more environmentally friendly actions. However, it should be noted that using a heated drawer also requires energy consumption to keep the ready foods at the desired temperature. It would be necessary to evaluate how much this consumption is significantly lower than that required to reheat the food in a conventional fashion, in order to avoid coming up with a solution that is incompatible with DfSB principles.

In general, most solutions presented involve automating the interaction between user and products and between products, in order to achieve a more rational use of environmental resources, restricting user behaviour. At this level of intervention, the control over behaviour is strongly associated with products, not emphasizing user learning and awareness. It should be noted, however, that eventual misunderstandings about product functions or the lack of user autonomy, may result in aversion or even sabotage during the usage phase.

Discussions on the ethics and responsibility of designers when influencing behavior, as well as the designers' feedback on their capacity to affect behavior, were among the workshop's last topics of discussion. Another issue discussed was the barriers faced by the company when considering the implementation of DfSB strategies in its design routine. The attendees answer to this question by pointing the technological cost as the main barrier for implementing DfSB in the cooking appliances.

There was also a critique of Loughborough's model linking the decision-making control axis and the levels of intervention. In this case, the participant exemplified that a user with a sustainable lifestyle might be more interested in products that automate and ensure the appropriate behaviour rather than taking the decisions oneself. This reflection provides an understanding that applying more DfSB strategies directly to the product, besides empowering change, can fill this gap.

Besides made it possible to achieve the second specific objective dealing with **to explore the implications of DfSB in terms of product innovation on a real-world industrial context**, the workshop 1 provided the C-Guidelines.

From the analysis and interpretation of propositions resulting from workshop 1, it was possible to establish the C-Guidelines for cooking products development towards more sustainable behaviours (Appendix VI).

These preliminary guidelines also considered the challenges, barriers, and advantages of Design for Sustainable Behaviour pointed out in the discussion with the group.

4.3.2 Workshop 2

The goal of second workshop was to create propositions and recommendations for implementing the DfSB guidelines derived from the previous stages. As prescribed in the protocol in Appendix IV, the study focused on the practices employed in the development of cooking appliances.

The meeting took place on January 27th, 2022 at Electrolux, in Curitiba, Brazil. It was attended by 8 senior-level professionals, including 2 industrial designers, 1 user experience designer, 1 user experience researcher, 1 service designer, and 1 design and sustainability researcher. The design manager and sustainability director completed the group.

The workshop introduction involved individual introductions, including the researcher and the cooking design experts who had previously attended workshop 1. Subsequently, the researcher carried out a 30-minute presentation on sustainable cooking definitions and habits, which later would be used on the ideation phase. (Figure 4.11).

FIGURE 4.11 – Workshop 2 | Ideation process

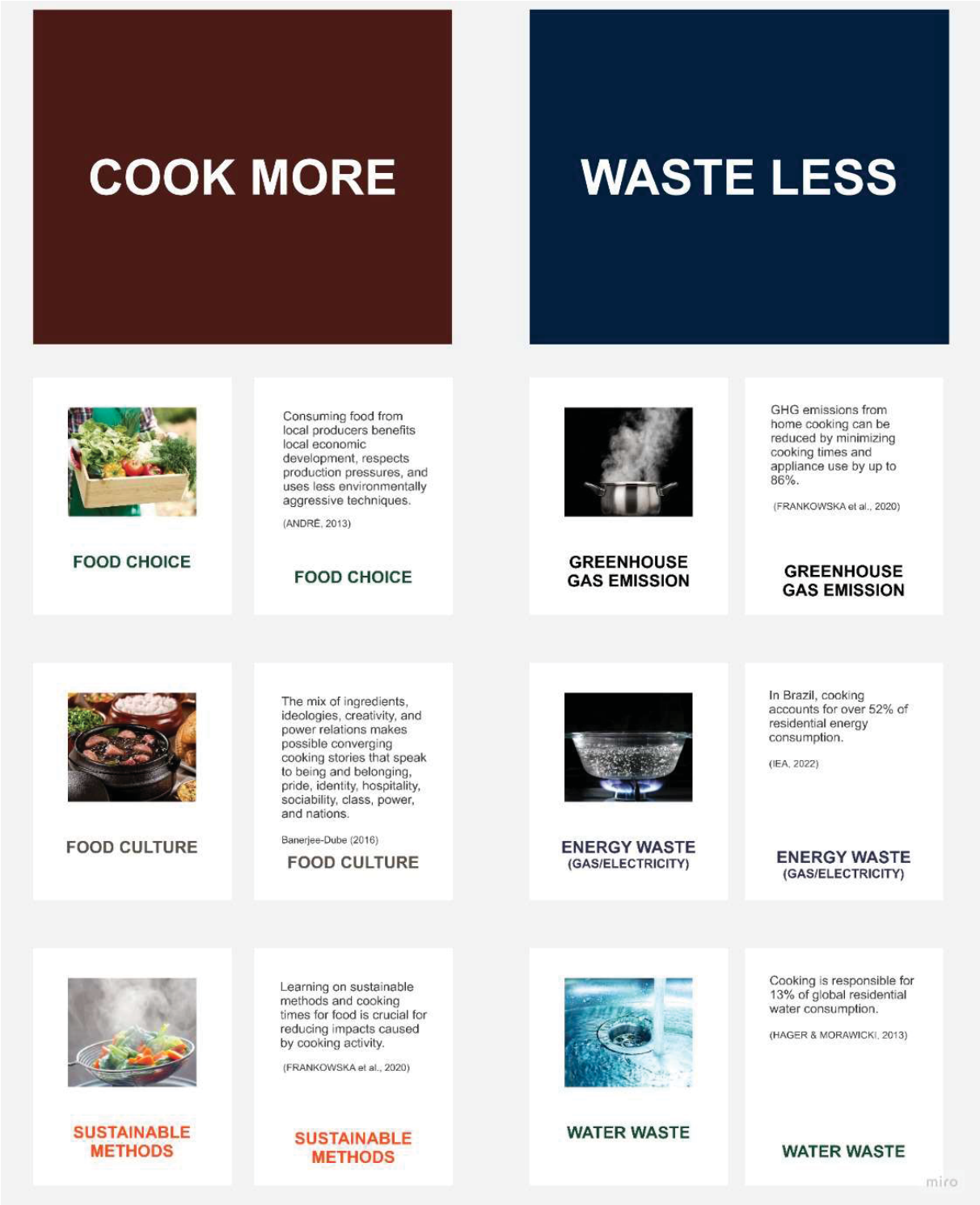
SOURCE: The author (2023).

The materials for the exercise included a persona representing the stove user, cards providing information about cooking habits and their impacts, and a board for proposals and discussion. The persona chosen for the activity, Roberta, was introduced in the first workshop (e.g., Figure 4.9, on p. 113) and was brought back due to how her characteristics matched the cooking habits discussed in the early presentation.

The primary goal of the dynamic was to find out recommendations to develop cooking products that would encourage a Brazilian user to adopt sustainable behaviors. The attendees were separated in 2 groups: "Waste Less" and "Cook More", according to the requirements described in Chapter 3 (e.g., Topic 3.3.3.2, on p. 96). The group's division was associated with intended cooking habits. Therefore, the Waste Less group was provided with habits such as water consumption, energy, and greenhouse gas emissions. The Cook More group accessed cards containing information on food choices, alternative sustainable methods of cooking, and cultural habits associated with cooking. Figure 4.12 shows the classification of groups and their respective cooking habits related.

.

FIGURE 4.12 – Cooking habit cards

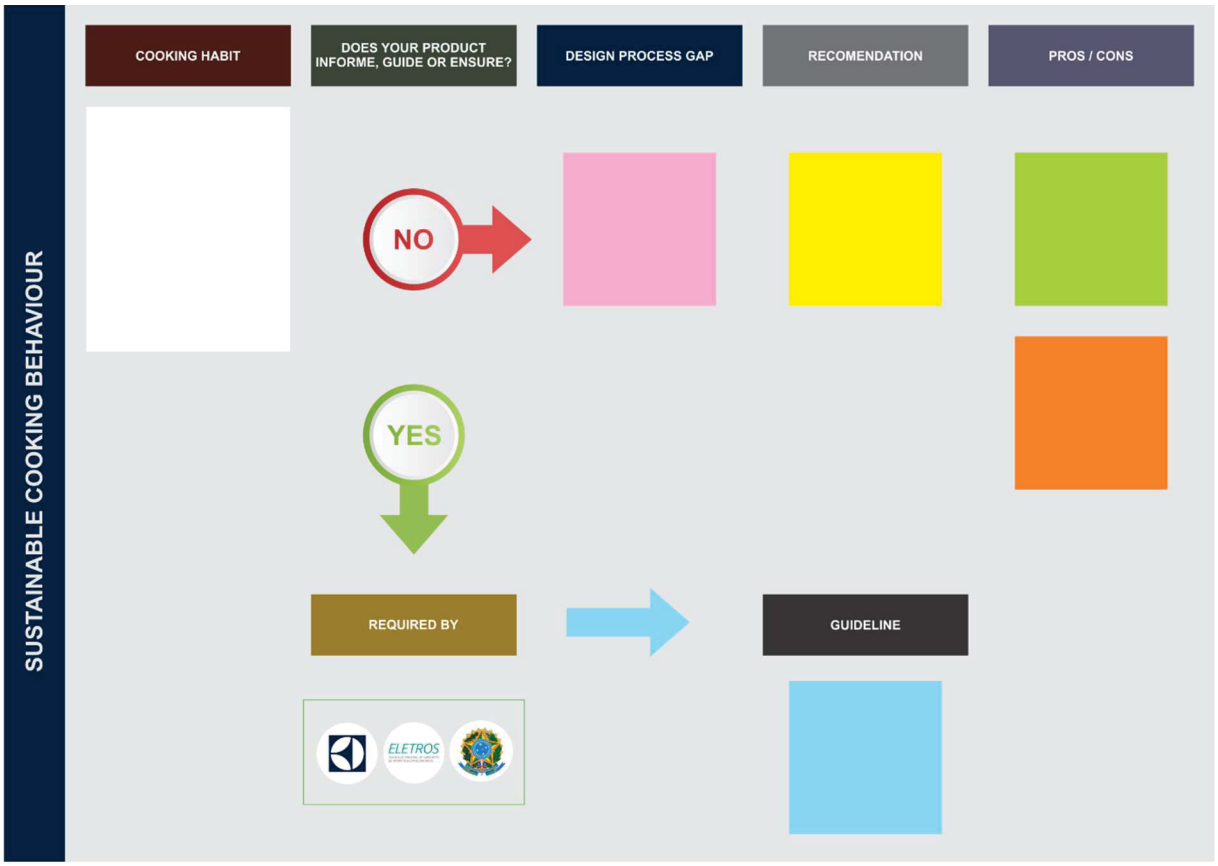


SOURCE: The author (2023).

Cooking habits and their impacts on sustainability were extracted from the literature review and presented to the participants through these cards in order to deepen their understanding about the problem. They also help on identifying gaps in the design process that amplify the repercussions of these impacts.

Each group received a work board (Figure 4.13) used for the exercise and for collecting the participants' notes. The participants should discuss if the persona's product, an Electrolux stove, offered any DfSB strategy aimed at a sustainable change in accordance with the selected cooking habit. Following the requirements described in Chapter 3 (e.g., Topic 3.3.3.2., on p. 96).

FIGURE 4.13 – Work board



SOURCE: The author (2023).

If the answer to this question was no, the participants should identify the gap within the design process that should be filled and propose recommendations. In case the product includes DfSB interventions, the participants should explain if it was required by the company, the industry sector, or the government through laws and regulations. This would make it feasible to bring attention to the company's procedures, evaluate its maturity level in terms of DFSB practices, and determine where it stands compared to other competitors. Additionally, it would be possible to comprehend the responsibilities imposed to manufacturers by governmental laws and regulations, including the sector's performance on sustainability.

After the two groups described their ideas, a mirror feedback was carried out. Each group analyzed the other's proposals and made their considerations including pros and cons. The resulted board is illustrated on Figure 4.14.

FIGURE 4.14 – Resulted board of ideas resulted from Workshop 2

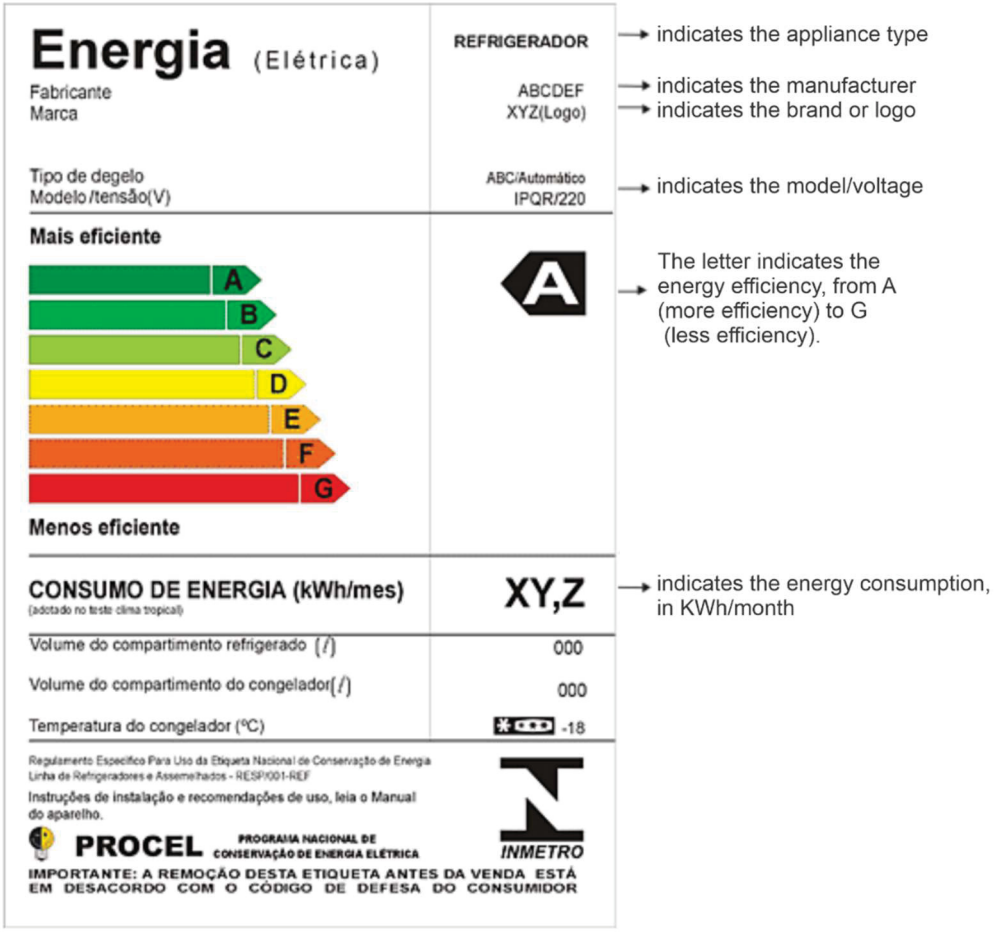
SOURCE: The author (2023). Available at: https://miro.com/app/board/uXjVPtyytF4=/

After making their considerations, there was a space for discussion among the participants to refine their ideas. According to the protocol (Appendix V), the groups had 10 minutes to propose recommendations and 30 minutes for the mirrored feedback and discussion.

The recommendations from this workshop provided subsidies for the development of the D-guidelines, based on the current processes and products of the company for the development of new cooking artifacts.

It is important to highlight that the only government regulation identified by the participants, that impacted the use of DfSB on cooking devices, was the need to use an energy efficiency label (Figure 4.15). The information veracity and easy visualization of this label in the products are inspected by the National Institute of Metrology, Quality and Technology (INMETRO), before the artifacts are sold and re-evaluated annually through auditories.

FIGURE 4.15 – Brazilian energy efficiency label



SOURCE: INMETRO (2021). Available at: https://www.gov.br/inmetro/pt-br/assuntos/avaliacao-da-conformidade/programa-brasileiro-de-etiquetagem/conheca-mais-sobre-a-etiqueta-do-pbe. Accessed in March, 2023.

This energy label aims to show the consumer the best energy efficiency levels of products, with a direct contribution to avoid excessive energy consumption. However, the group discussion unveiled those interventions applied directly to the product, stimulating the user's decision control, could be more effective in educating the consumer to reflect on their actions and responsibility, influencing sustainable behaviors, as pointed out by Bhamra, Lilley & Tang (2011).

Another important point to note is that the national and international survey in cooking devices have shown there is a low level of adherence to DfSB strategies. Indeed, the results allow us to conclude that the level of DfSB maturity in cooking appliance producers is still incipient. This gap characterizes an opportunity for the company to adopt an approach aimed at increasing its sustainable potential within the Design for Sustainability framework. In this sense, it could also enable the company to position itself ahead of its competitors on a global level.

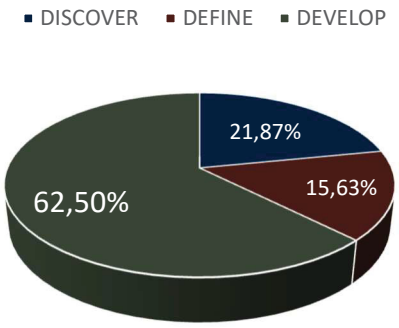
The result of analysis and interpretation of the proposals and recommendations from workshop 2 are presented in Appendix VIII.

4.4 PHASE 4 | DEVELOPMENT

The development of version 1.0 of the guidelines occurred from the cross-analysis of the preliminary versions (A, B, C, and D guidelines) of each research stage, which resulted in a total of 95 guidelines. This cross-analysis (Appendix IX) aimed to group them into a single document, keeping their classification according to the stages of the Double Diamond design process and verifying the saturation or degree of repetition of the guidelines. From the categorization, it was possible to qualify and identify similarities, differences, particularities, and complementarities to propose the final version of the guidelines.

Initially, through a holistic analysis the results, it is possible to state that the "develop" category presents the largest number of guidelines, 52. The "define" category comprises 26 guidelines, and the "discover" category comprises 17. It is important to point out that all stages of the research contributed to all the categories. The theoretical base contributed mainly to the "develop" category, which includes 20 guidelines from translating principles, concepts, and strategies discussed in the literature review. This result represents 62.5% of the total (Graphic 4.1). It highlights the importance of converting generalist concepts in Design for Sustainable Behavior to specific sectors' specific demands to expand the adoption of DfSB strategies in the development of new products.

GRAPHIC 4.1 – A-Guidelines' categories distribution

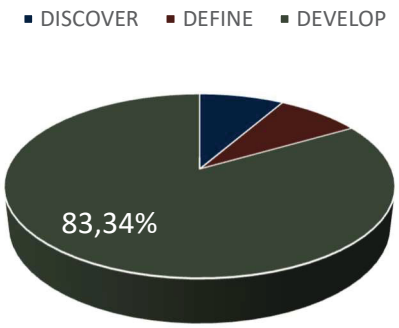


SOURCE: The author (2023).

A significant number of guidelines obtained through the Survey, 10 out of 12, are associated with the "develop" category (Graphic 4.2). The comparative analysis sought to

identify the applications of DfSB strategies, observing characteristics and functions of the products that are defined mainly in the "develop" stage of the design process. Therefore, the main directions coming from the Survey guide the designer, mainly in the stage of conceptualization and propositions of solutions.

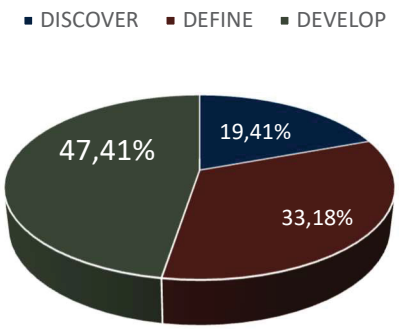
GRAPHIC 4.2 – B-Guidelines' categories distribution



SOURCE: The author (2023).

The first creative workshop with the Electrolux design team presented a more balanced distribution of guidelines among the categories (Graphic 4.3). Although the main focus of the dynamic was concentrated on the proposition of solutions for the products, the theoretical presentation for the alignment of knowledge between the academy and industrial practice, as well as the space dedicated to discussion with designers from different areas and reflection about the designer's role in influencing behavior, contributed to this balance.

GRAPHIC 4.3 – C-Guidelines' categories distribution

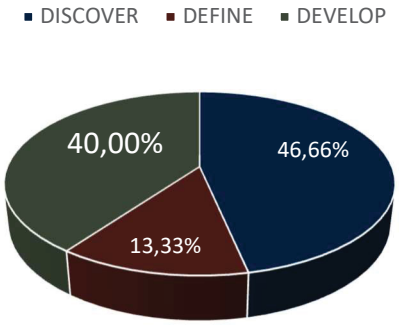


SOURCE: The author (2023).

As for workshop 2, it is important to note that it had a higher concentration of guidelines in the categories "discover", 14, and "develop", 12 (Graphic 4.4), highlighting the importance of the theoretical basis for the stage of understanding the problem and how the DfSB strategies should be applied in cooking products. The cooking experts' perspective

allowed enriching the contributions to developing the guidelines, looking at particular problems of their areas, which impact the others in the product development.

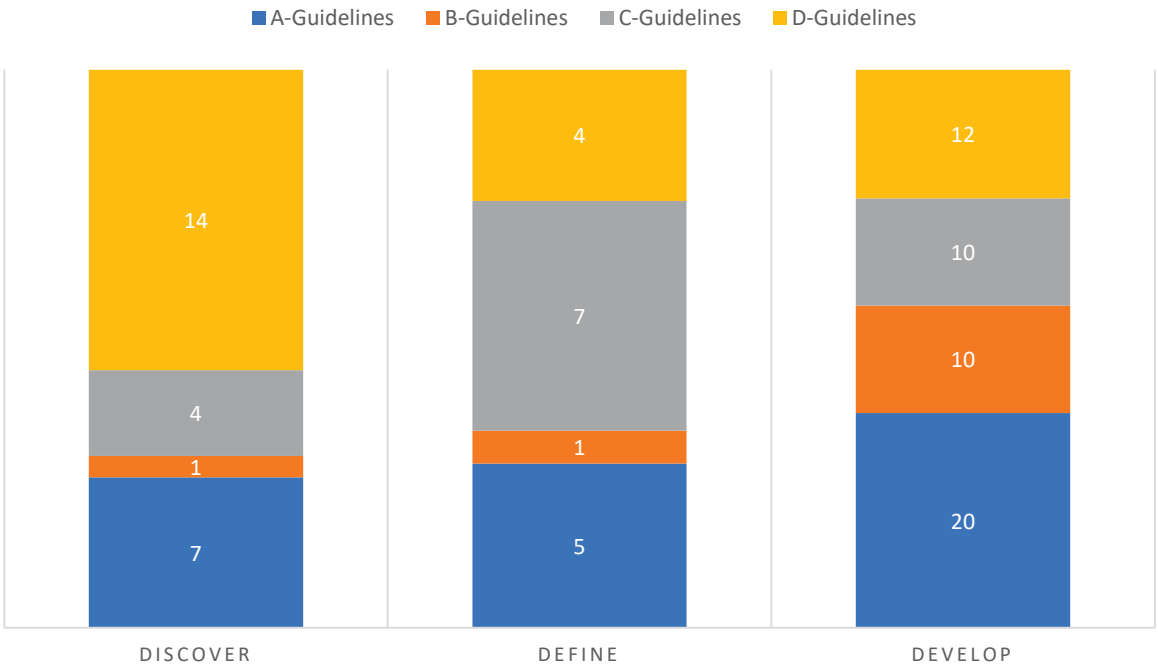
GRAPHIC 4.4 – D-Guidelines' categories distribution



SOURCE: The author (2023).

Considering the number of guidelines created, there is a significant contribution from the theoretical base (A-guidelines) and workshop 2 (D-guidelines), 32 and 30, respectively. This total represents more than 65% of all the guidelines analyzed in this 1.0 version. Graph 4.5 shows that workshop 2 contributed significantly to the 'discover' category, while the theoretical basis provided greater robustness to the 'develop' category.

GRAPHIC 4.5 – Preliminary guidelines and their distribution in the categories of design process



SOURCE: The author (2023).

Among the findings, 11 similarities (A6 and D6; D10 and A7; A6 and D7; A20 and B4; B6 and A14; A32 and B12; A20 and C12; A32 and B12; C12 and A18; B7 and C13; A28 and D25)

and 28 complementary guidelines were observed (D8 and D7; A3 and D9; D12 and D13; A20 and A21; A23 and A29; A14 and B9; B10 and A15; A15 and A17; D15 and D16; A14, B6 and B9; A15 and B10; A22 and D22; A24 and D23; A32 and D30). Table 4.2 shows version 1.0 of the guidelines, after the adjustments mentioned.

TABLE 4.2 – Guidelines' version 1.0

Nº	GUIDELINES	SOURCE	DESIGN STEP
1	Influence behavioral changes with a focus on satisfying the user's needs and desires in harmony with the pillars of sustainability.	SCHERER, 2023; VEZZOLI et al., 2018 (A1).	DISCOVER
2	Increase the knowledge about the user's experiences, motivations, and needs.	REDSTRÖM, 2006 (A2).	DISCOVER
3	Understand the user's behavior and the context in which the product is used.	WEVER, 2012; MEDEIROS et al., 2018 (A3); WS2 (D9).	DISCOVER
4	Learn about users' mental models.	WEVER, 2012; MEDEIROS et al., 2018 (A4).	DISCOVER
5	Understand sociological and psychological aspects that affect the user.	SANTOS et al., 2018 (A5)	DISCOVER
6	Understand consumption habits and all the resources impacts during the cooking activity.	TANG & BHAMRA, 2012 (A6); WS2 (D6, D7 and D8).	DISCOVER
7	Understand aspects of globalization, local cultures, and socio-environmental impacts.	SANTOS et al., 2018 (A7); WS2 (D10).	DISCOVER
8	Understand the user maturity level for sustainability.	SURVEY (B1).	DISCOVER
9	Understand levels of the behavioural change and DfSB strategies.	WS1 (C1).	DISCOVER
10	Understand behavioural theories that support individual change, contextual change or both.	WS1 (C2).	DISCOVER
11	Understand the differences between behaviour and habitus.	WS1 (C3).	DISCOVER
12	Know the fields of the DfSB approach.	WS1 (C4).	DISCOVER

Nº	GUIDELINES	SOURCE	DESIGN STEP
13	Analyse if the briefing proposes the application of DfSB strategies in the product.	WS2 (D1).	DISCOVER
14	Analyse if DfSB strategies are required by the company, industry sector, or government institutions.	WS2 (D2).	DISCOVER
15	When redesigning products, analyse if the current artefact features DfSB interventions and evaluate the potential for amplifying the strategies.	WS2 (D3).	DISCOVER
16	Work with a culturally diverse design team in cooking product development.	WS2 (D4).	DISCOVER
17	Investigate gaps in the design process that may provide opportunities for sustainable change.	WS2 (D5).	DISCOVER
18	Conduct ethnographic research to understand social phenomena that affect cultural habits and user behaviour.	WS2 (D11).	DISCOVER
19	Learn and test sustainable cooking methods to influence users adopt them.	WS2 (D12 and D13).	DISCOVER
20	Map and analyse the user decisions that impact the practice of cooking in the user journey.	WS2 (D14).	DISCOVER
21	Define if the behaviour change is occasional or involves a change of habits.	JACKSON, 2005 (A8).	DEFINE
22	Identify the factors that influence and shape consumer decision-making.	BHAMRA & TANG, 2008 (A9).	DEFINE
23	Translate the perceptions of use in the early project phase.	WEVER, 2012; MEDEIROS et al., 2018 (A10)	DEFINE
24	Identify new social demands that promote the inclusion of vulnerable populations.	SAMPAIO et al., 2018 (A11).	DEFINE
25	Promote local community empowerment.	SANTOS et al., 2018 (A12).	DEFINE
26	Define the desirable behaviour to select the appropriate DfSB strategy.	SURVEY (B2)	DEFINE

Nº	GUIDELINES	SOURCE	DESIGN STEP
27	Making DfSB knowledge accessible to the company's designers.	WS1 (C5).	DEFINE
28	Consider the designer's skills in influencing behaviour.	WS1 (C6).	DEFINE
29	Define if the focus of change is on the individual, contextual, or both.	WS1 (C7).	DEFINE
30	Identify the consumer's maturity level on sustainability.	WS1 (C8)	DEFINE
31	Consider the user's interest in adopting new behaviours.	WS1 (C9)	DEFINE
32	Understand which energy sources are suitable for the device's most sustainable use.	WS1 (C10)	DEFINE
33	Align DfSB strategies with professionals involved in product development.	WS1 (C11).	DEFINE
34	Evaluate the risks of proposing solutions restricted to regional cultural habits and the risks of ignoring these aspects.	WS2 (D15 and D16).	DEFINE
35	Investigate and use technologies capable of converting information on cooking habits into data.	WS2 (D17).	DEFINE
36	Disseminate good practices of sustainable cooking.	WS2 (D18).	DEFINE
37	Develop solutions in an ethical, empathetic, and responsible manner.	SANTOS et al., 2018 (A13).	DEVELOP
38	Make it easy for users to adopt sustainable behaviours by proposing a personalised approach to increase their identification and engagement with the behavioural change process.	NIEDDERER et al. 2014; BHAMRA et al., 2011 (A14); SURVEY (B6 and B9).	DEVELOP
39	Impose difficulties for users to perform unsustainable behaviours, avoiding to restrict their autonomy while using the appliance.	NIEDDERER et al. 2014; BHAMRA et al., 2011 (A15); SURVEY (B10).	DEVELOP
40	Make users want to adopt sustainable behaviour, avoiding that they prefer to perform in an unsustainable way.	NIEDDERER et al. 2014 (A16 and A17).	DEVELOP
41	Make the consumption of resources visible, understandable, and accessible to the user.	BHAMRA et al., 2011 (A19).	DEVELOP

Nº	GUIDELINES	SOURCE	DESIGN STEP
42	Encourage users to reflect on their consumption and the responsibility of their action during usage.	BHAMRA et al., 2011 (A20); FRANKOWSKA et al., 2020 (A18); SURVEY (B4); WS1 (C12).	DEVELOP
43	Educate and encourage users to adopt clean energy sources for cooking.	MAES AND VERBIST, 2012 (A22); WS2 (D22).	DEVELOP
44	Stimulate users culinary learning and skills in a sustainable way, encouraging they to keep their traditions.	KATZ & WEAVER, 2002; HART, 2019 (A23); CARAHER & LANG, 1999 (A29).	DEVELOP
45	Inspire users to explore more sustainable usage practices through learning appropriated cooking methods, educating them on appropriated methods	BHAMRA et al., 2011 (A24); WS2 (D23).	DEVELOP
46	Encourage gender equity in the cooking activity.	GALLUP, 2021 (A25)	DEVELOP
47	Educate users about the benefits of home cooking.	KOLODINSKY & GOLDSTEIN, 2011; POLLAN, 2013; PLESSZ & ÉTILÉ, 2019; SARDA et al., 2022; LAVELLE et al., 2016; HART, 2019; GATLEY et al., 2014; KRAMER et al., 2012; SIMMONS & CHAPMAN, 2012; WOLFSON & BLEICH, 2015 (A26).	DEVELOP
48	Discourage the cooking of ultra-processed foods and foods with low nutritional value.	SMITH & POPKIN, 2013; THARREY et al., 2020; STITT, JEPSON, PAULSON-BOX, & PRISK, 1996; BLYTHMAN, 2013 (A27)	DEVELOP
49	Promote a culinary experience that values cultural identity, local conditions, and the feeling of cooking something unique.	LÉVI-STRAUSS, 1968; MACIEL, 2004; FREYRE, 2006; BRILLAT-SAVARIN, 2009; CASCUDO, 2016 (A28); WS2 (D25).	DEVELOP
50	Educate the user on the benefits of local and seasonal food consumption.	ANDRÉ, 2013; GATLEY et al., 2014 (A30).	DEVELOP
51	To promote attitudinal change towards decentralisation of the economy and fair trade.	SANTOS et al., 2019 (A31).	DEVELOP
52	Measure the effectiveness of the DfSB strategies applied and monitoring product field tests to identify opportunities for improvement.	LIDMAN & RESTRÖM, 2011; NIEDDERER et al., 2014; WEVER, 2012; MEDEIROS et al., 2018 (A32); WS 2 (D30); SURVEY (B12).	DEVELOP
53	Make clear to users the motivations of product design for sustainability.	SURVEY (B3).	DEVELOP
54	Broaden users' understanding of the responsibility of their individual actions and the direct impacts on sustainability.	SURVEY (B5).	DEVELOP

Nº	GUIDELINES	SOURCE	DESIGN STEP
55	Boosting behaviour change through the application of several DfSB strategies.	WS1 (C13); SURVEY (B7).	DEVELOP
56	Prefer to apply DfSB interventions to the product that interact with the user.	SURVEY (B8).	DEVELOP
57	Inform the user, in a transparent way, of the company's actions towards sustainability.	SURVEY (B11).	DEVELOP
58	Educate users on the carbon footprint produced by the cooking method chosen.	WS1 (C14).	DEVELOP
59	Guide the user in choosing the right pan size for the burner powers.	WS1 (C15).	DEVELOP
60	Make accessible to users the appropriate water measurements for their chosen meal and cooking method.	WS1 (C16).	DEVELOP
61	Consider residual heat use.	WS1 (C17).	DEVELOP
62	Test the performance of the artifact from a combination of more sustainable cooking methods and fuel sources.	WS1 (C18).	DEVELOP
63	Analyze the barriers that may invalidate the implementation of DfSB strategies.	WS1 (C19).	DEVELOP
64	Evaluate the undesirable behaviours that may be triggered by the DfSB strategies selected.	WS1 (C20).	DEVELOP
65	Document the lessons learned from the application of the DfSB interventions.	WS1 (C21).	DEVELOP
66	Make visible the consumption of resources during cooking practice.	WS2 (D19).	DEVELOP
67	Propose interventions that would benefit the reduction of resource consumption used during the cooking task.	WS2 (D20).	DEVELOP
68	Inform the user about the possibilities of reusing water spent during cooking.	WS2 (D21).	DEVELOP
69	Educate the consumer on more sustainable and responsible decisions when choosing food.	WS2 (D24).	DEVELOP
70	Customise the artifact to broaden the scope of sustainable habits.	WS2 (D26).	DEVELOP

Nº	GUIDELINES	SOURCE	DESIGN STEP
71	Propose solutions aligned with the company's sustainable strategy and the local context of product use.	WS2 (D27).	DEVELOP
72	Avoid providing excessive or unnecessary information to the consumer while using the product.	WS2 (D28).	DEVELOP
73	Evaluate the impacts for sustainability in solutions targeting more economical or faster cooking.	WS2 (D29).	DEVELOP

SOURCE: The author (2023).

Notice that guidelines with similar statements were merged into a single statement.

4.5 PHASE 5 | EVALUATION

To assess the feasibility of the guidelines in industrial practice, the group of cooking product experts from Electrolux (Table 4.3) who participated in workshops 1 and 2 were invited to an online meeting, with a scoreboard applied on a collaborative virtual platform (Appendix VI) to analyze: (a) the consistency between the guideline and the cooking product development practice; (b) the usefulness of the guidelines to support the designer's decision making process; (c) the usefulness of the guideline to support the development of competencies on DfSB among new designers; (d) the practical contribution of the guidelines to foster innovation through DfSB strategies.

TABLE 4.3 – Profile of Experts in Cooking Appliance Design

QT	ELECTROLUX FOOD PREPARATION DESIGN TEAM
1	Head of Sustainability
1	Design Manager
2	Senior Industrial Designer
1	Principal UX Designer
1	UX Design Researcher
1	Design & Sustainability
1	Senior Service Designer

SOURCE: The author (2023).

The meeting took place in March 2023. Based on the defined evaluation criteria, the experts made suggestions for improvements and adjustments to refine the guidelines. In general, the professionals highlighted the relevance of the DfSB guidelines for cooking products, which may be extended to the scope of other company product categories in the future. The group agreed that most of the guidelines are coherent with developing cooking products and have a high degree of support in the decision-making of designers and in the instruction of new professionals. Regarding the contribution to learning, the specialists pointed out that the guidelines:

- Help to create awareness on the importance of encouraging sustainable behavior.
- Enable designers to apply their DfSB knowledge to develop new products;
- Reinforce the need to influence sustainable change and advocate for implementing innovations;
- Make it possible to keep the products constantly in evolution, generating learning for the team and broadening knowledge on DfSB;
- Support the formulation of project requirements and target goals;
- Expand the team's knowledge on other cultures and thus improve the team's ability to create products that meet the users' needs in different parts of the world;
- Contributes to the identification of market opportunities that might otherwise go unnoticed;
- Collaborate in identifying critical points, opportunities for innovation, and project direction to generate alternatives with less impact on sustainability;
- Allow the development of more assertive solutions;
- Call attention to the relevance of assessings risks about peculiarities of local habits and culture that may signal opportunities for the company to be more comprehensive and inclusive;
- Help the design team to understand the benefits, limitations, and challenges of influencing behavior for sustainable cooking;
- Facilitate the designer to transmit this learning to the user through product interventions or communication, through the knowledge gained in DfSB.
- Allow creating personalized experiences for users and satisfying their needs.

Regarding suggestions for improvement and refinement, the professionals observed that guidelines 9 and 27, that deal with "Understanding levels of the behavioral change and DfSB strategies" and "Making DfSB knowledge accessible to the company's designers" are interdependent due to the fact that making information available (27) does not necessarily mean generating knowledge and neither applicability.

There were doubts concerning the clarity of guideline 28 about "consider the designer's skills in influencing behavior" and 36 that instructs "disseminate good practices of sustainable cooking". The group's suggestion was to revise them, bringing more clarity and facilitating the designer's understanding.

Related to guideline 12 (Know practical examples employing DfSB strategies), initially, one of the participants did not identify that this guideline helps the designer's decision-making. However, knowing the fields of the DfSB approach allows the Designer to conceive solutions that enable the user to explore possibilities beyond the product boundaries. In this sense, knowledge about the fields of action supports the designer's decision to propose solutions oriented to products, services, systems, or social innovation.

Some results of version 1.0 were identified as product design heuristic or strategies rather than generic design process guidelines. The experts observed this in guidelines 18, 43, 45, 58, 66, 68, and 69. Indeed, these guidelines were mainly derived from the theory about DfSB strategies. Hence, the experts' recommendation was to reformulate the information provided in the guidelines in order to avoid mistakes between DfSB strategies aiming at product design and DfSB guidelines aiming at the Design process.

Among the alternatives that did not meet most of the evaluation criteria are 32, 35, 59, 60, and 61. According to the evaluators, they present solution characteristics and should not be included as guidelines. Considering the classification according to the design process, the group observed that guidelines 33 (align DfSB strategies with professionals involved in product development) and 63 (analyze the barriers that may invalidate the implementations of DfSB strategies) are pertinent to the 'discover' stage since they are recommendations that need to be considered at the beginning of the project.

One of the professionals highlighted guideline 73 as ambitious and challenging because it deals with "evaluate the impacts for sustainability in solutions targeting more economical or faster cooking". However, the use of DfSB strategies such as eco-feedback, which makes it possible to inform the user of consumption in real-time, providing data and information about

consumption history, could help create a database that would allow assessing the impacts and effectiveness of DfSB employed into products.

According to the results of the evaluation stage, the specialists, when individually evaluating the propositions, were very critical, particularly with the results of the workshops, in which all of them actively participated. They also recommended standardizing vocabulary concerning users and consumers and appliances, artifacts, and equipment.

4.6 PHASE 6 | REFLECTION

4.6.1 Contributions to the household appliance industry

The current scenario of the household appliance industry, from a sustainability perspective, is heavily directed to satisfy regulations and legislation involving mainly the disposal of products. Advances in sustainability have occurred slowly, as evidenced by the waste disposal law (Number 12,305) published in August 2010, which was regulated in the appliance sector only with the regulation no. 10,240 of February 2020.

In this sense, the proposed guidelines present a relevant contribution for those companies in the sector willing to advance their contributions towards sustainability beyond regulation compliance. Their evolution can occur not only through eco-design practices but also by helping professionals in the area to deepen their understanding on the potential design contributions to influence the rational use of resources on the appliance's usage phase, responsible for significant impacts on sustainability.

By encouraging the user to behave in a more sustainable way without having to rely solely on governmental requirements, the industry could actively position itself as highly committed to the goals of sustainable development. Paradoxically it might demand that the industry promotes policies and programs that result in legislation and regulation that stimulate wider adoption of DfSB strategies.

Another benefit that the guidelines can provide is the possibility to understand the level of maturity of a given company regarding Design for Sustainability. Such understanding is useful to stimulate the industry to broaden the scope of the industry's artifacts, including services, product-services systems, and social innovation. Knowing the maturity level in Sustainable Design allows the company to establish goals and indicators to evaluate its

evolution and advance within this theme, including the development of competencies on its own staff. Indeed, the proposed set of guidelines allows companies in the sector to identify the necessary competencies for the professionals responsible for influencing behavioral changes toward sustainability.

Considering the climate urges, the contribution of the guidelines to educate and influence users to reflect about the environmental, social and economic impacts associated with their consumption, provides an opportunity to develop solutions that could bring the user to be more actively involved in reducing such impacts.

4.6.2 Skills required from the designer for the practical application of the guidelines

The concept of competence involves aspects related to theoretical knowledge, knowing how to do it (skills), and knowing how to be (attitude). In this sense, the literature and the observations carried out during the workshops allow to conclude that the main competencies required for the application of the DfSB guidelines involve the following:

- Capacity to identify changes in habits and changes in behavior.
- Capacity to identify the motivators in the users' decision-making.
- Capacity to select the most appropriate DfSB for a particular behaviour change goal;
- Capacity to antecipate and avoid unsustainable behavior.
- Capacity to map and characterize consumer habits and cultural habits.
- Capacity to understand sociological and psychological aspects of globalization, local cultures, and socio-environmental impacts.
- Capacity to develop solutions in an ethical, empathetic, and responsible manner;
- Ability to develop solutions for sustainable behaviors capable of satisfying the user's needs and desires.

In conclusion, some of the Designer skills to apply the DfSB guidelines are intrinsic and usually expected from the generic profile of the profession. However, the workshops have shown the development of the specific competencies on DfSB remains a challenge for the advancement of the current and future professionals towards high level competencies on Design for Sustainability.

4.6.3 Contributions toward expanding generalist theory of Design for Sustainable Behaviour

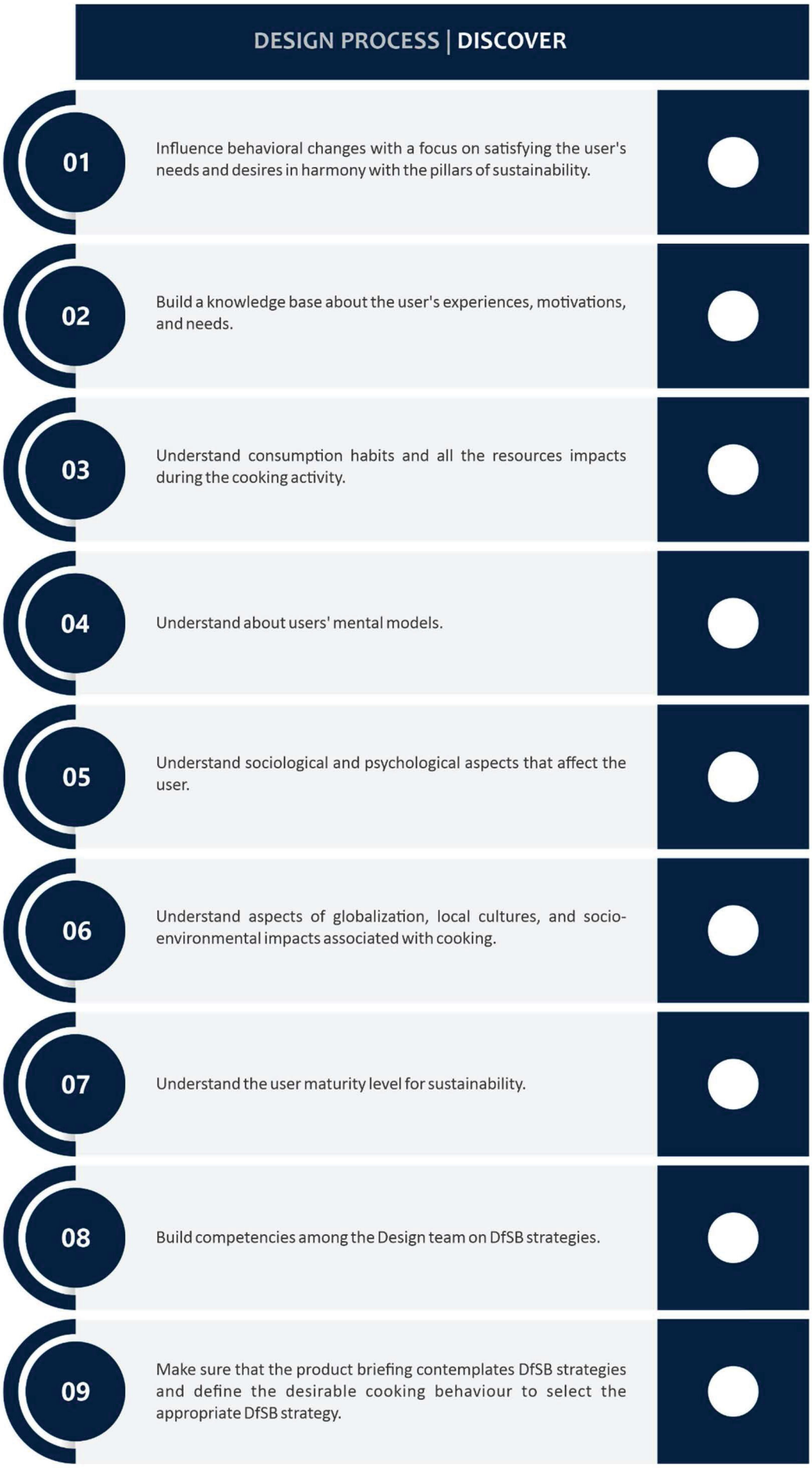
There were no contributions targeted at expanding the generalist DfSB theory. However, there are contributions to Design for Sustainable Behaviour concerning the Double Diamond design process and key considerations of training and development of designers as well as advancing business documentation and process in DfSB in the Develop stage. Also, there is a contribution to the area of the effect of culture on the adoption of DfSB strategies.

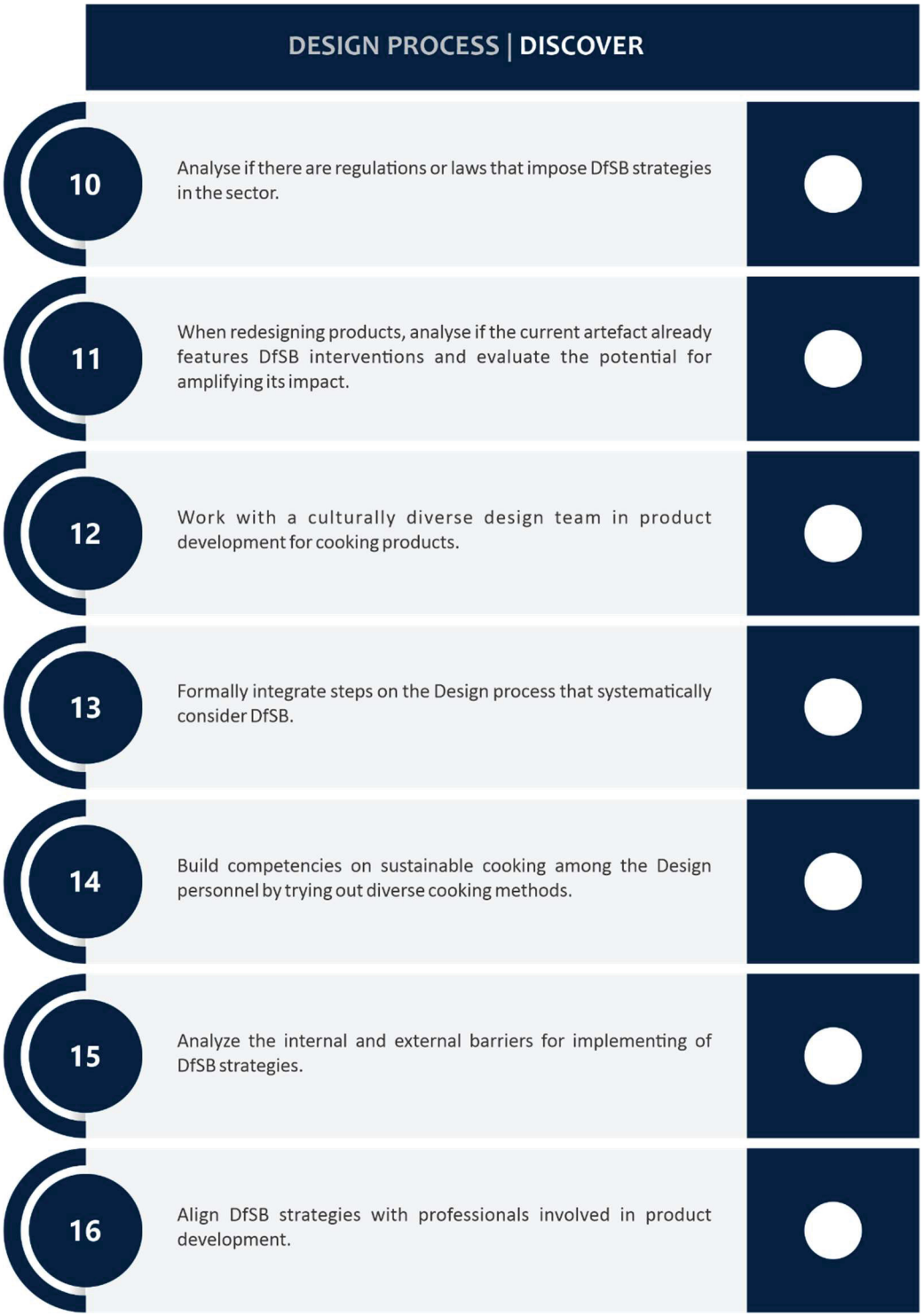
The flow down of this generic theory into a specific sector does constitute a topic that requires theoretical contributions. The case of the white appliances investigated in this dissertation exemplify this space knowledge contribution that awaits further Design research, given that the industry has not yet sufficiently explored the application of DfSB strategies. Future studies based on the measurement of the application of strategies in the sector may contribute to the expansion of the theory in DfSB and enable further refinement of the proposed guidelines.

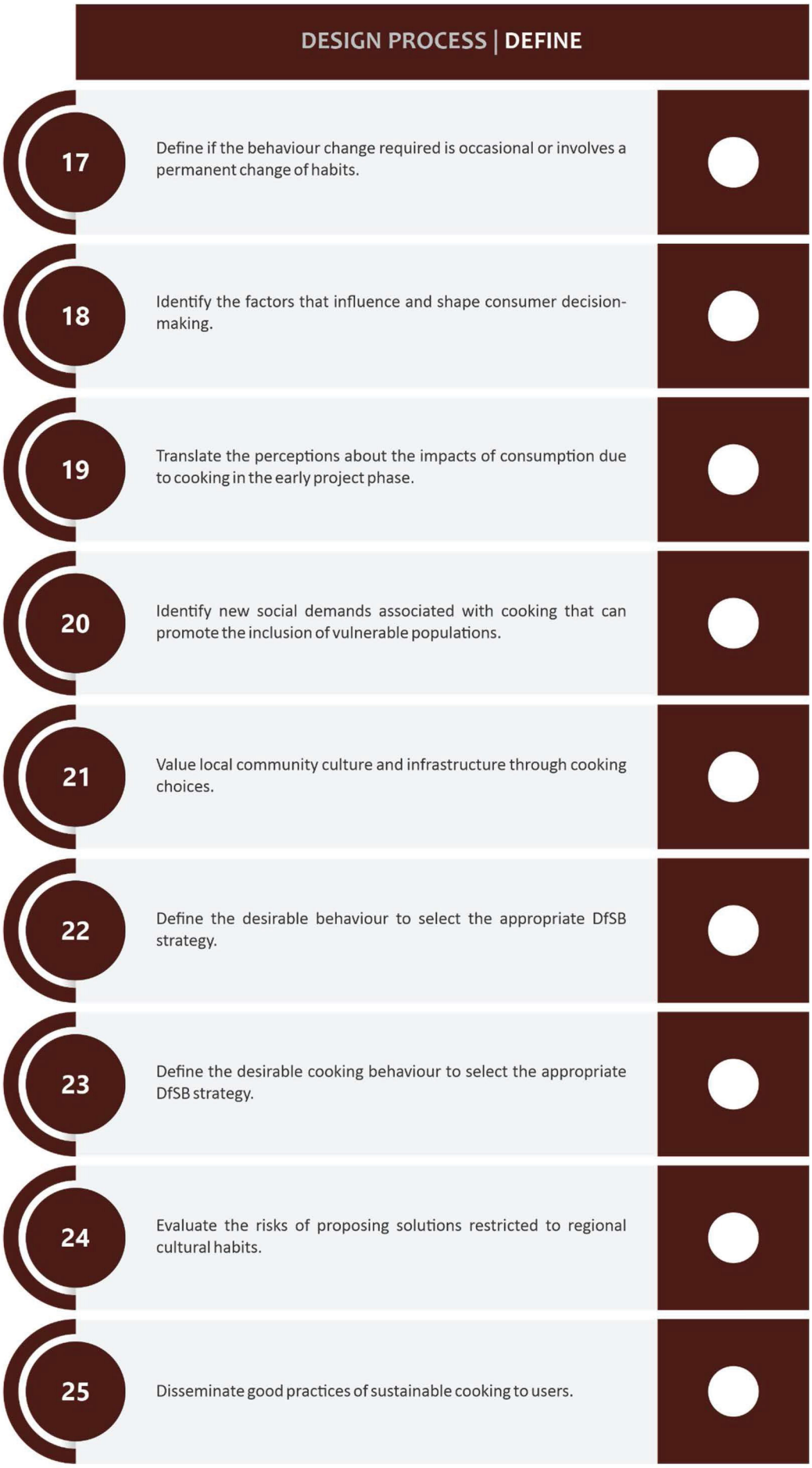
4.6.4 Final version of guidelines

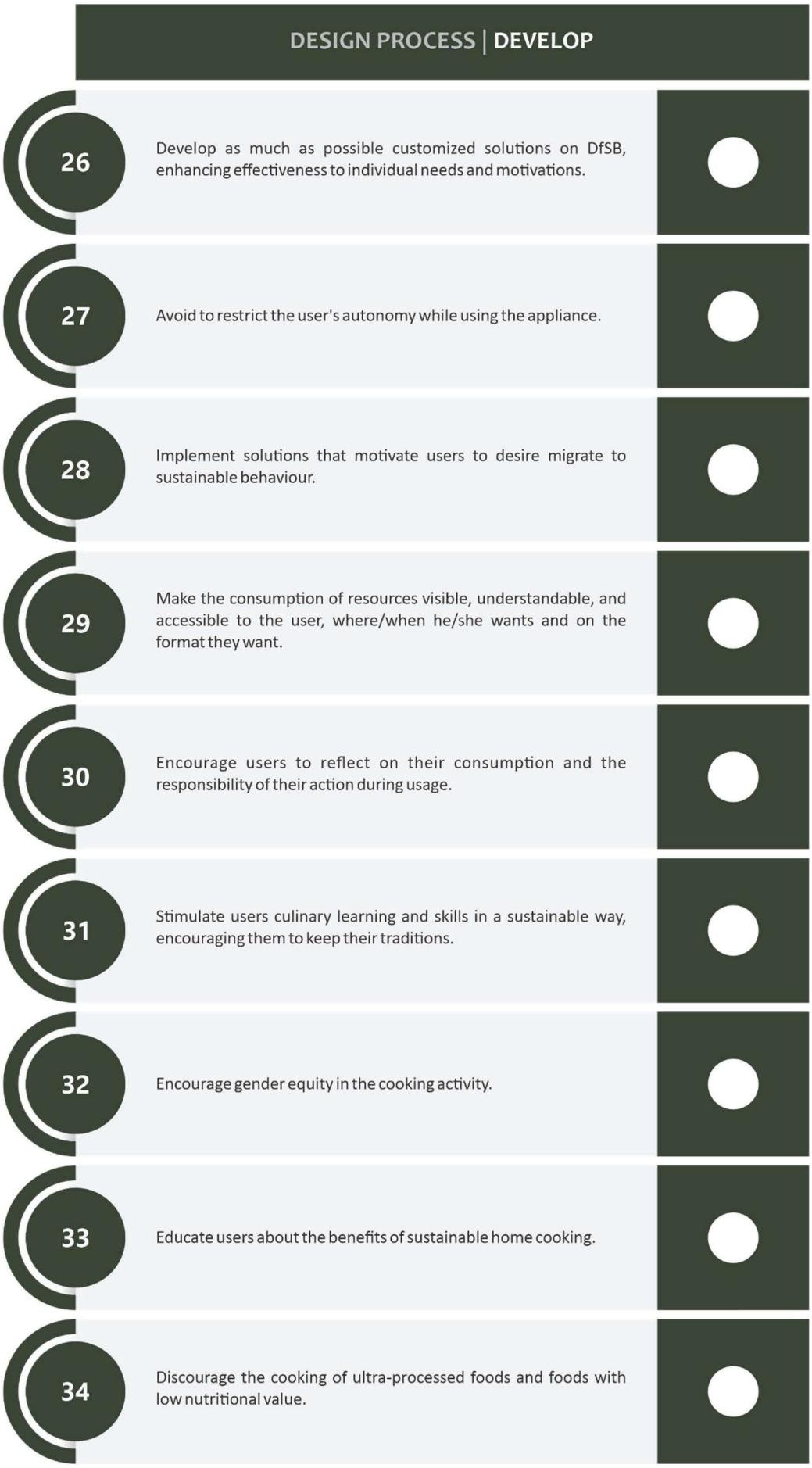
The final list of guidelines is shown in Figure 4.16, taking into account the observations pointed out in the evaluation stage and improvements derived from the comparison with the literature reviewed. The artifact is presented in checklist format for easy understanding and application in a practical context.

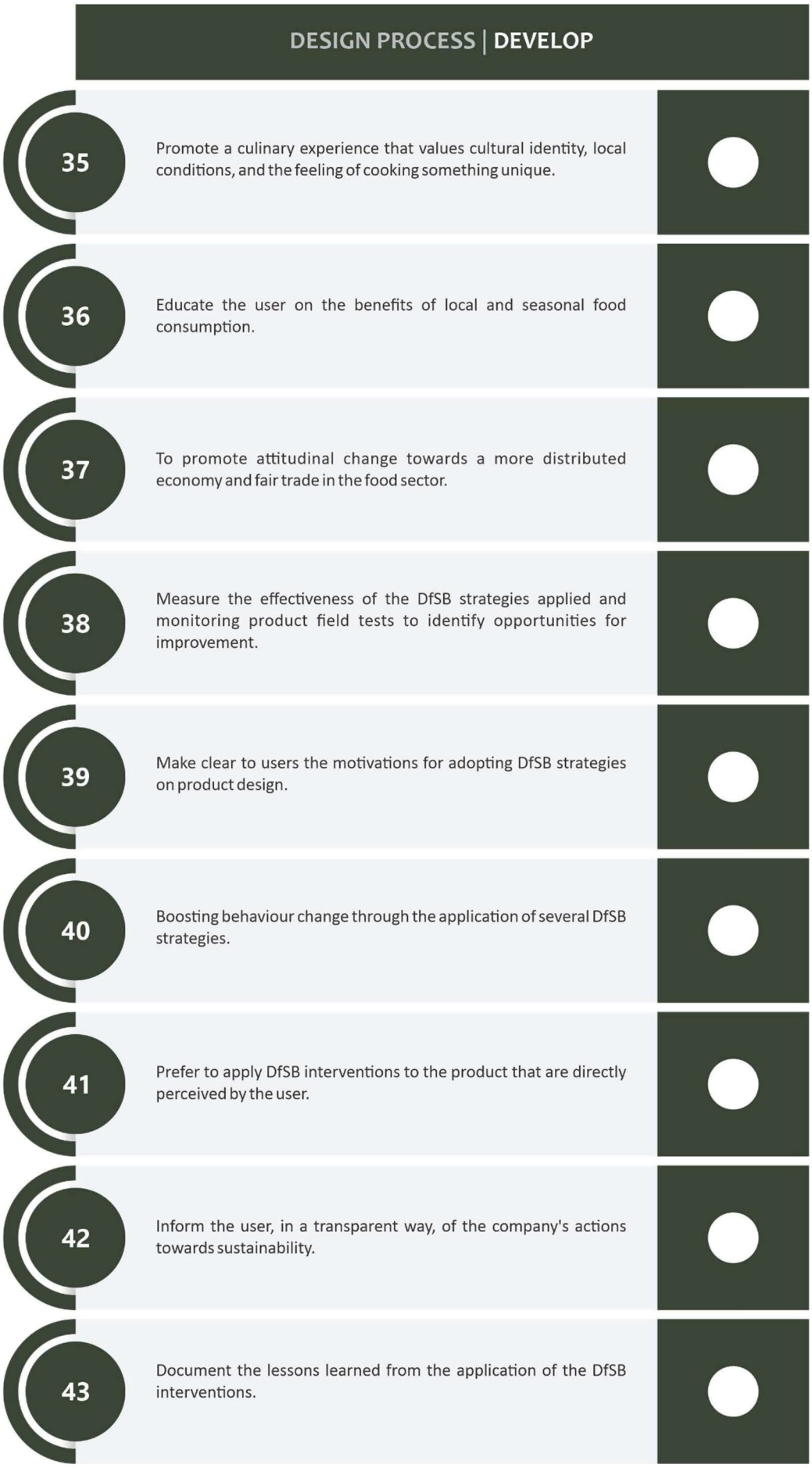
FIGURE 4.16 – Final version of guidelines

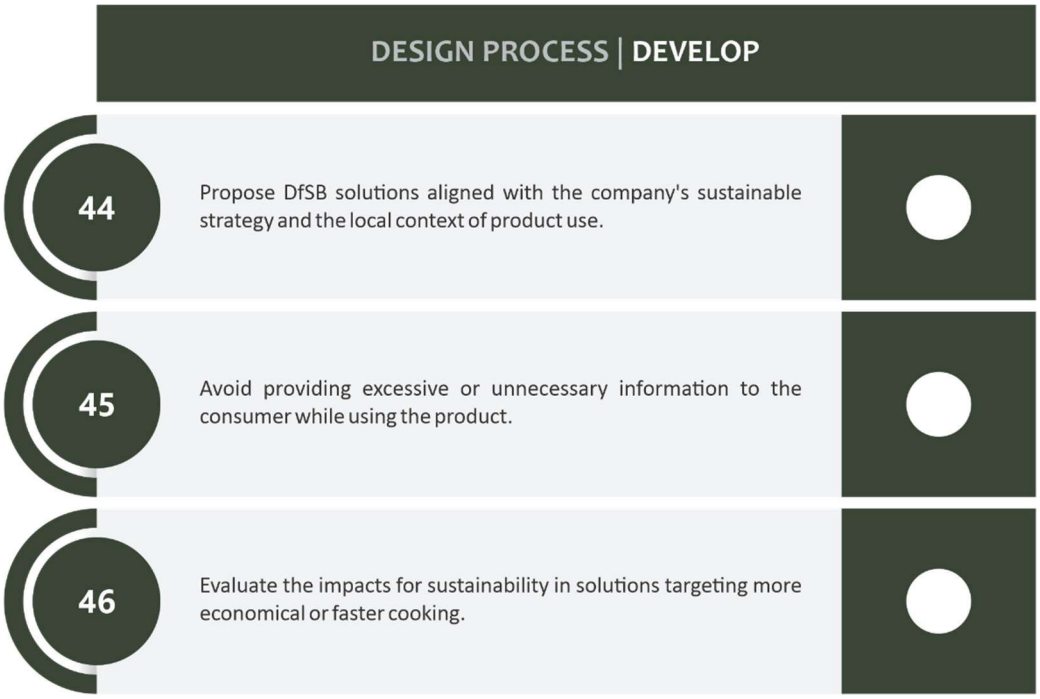

DESIGN PROCESS | DISCOVER
01
Influence behavioral changes with a focus on satisfying the user's needs and desires in harmony with the pillars of sustainability.
02
Build a knowledge base about the user's experiences, motivations, and needs.
03
Understand consumption habits and all the resources impacts during the cooking activity.
04
Understand about users' mental models.
05
Understand sociological and psychological aspects that affect the user.
06
Understand aspects of globalization, local cultures, and socio-environmental impacts associated with cooking.
07
Understand the user maturity level for sustainability.
08
Build competencies among the Design team on DfSB strategies.
09
Make sure that the product briefing contemplates DfSB strategies and define the desirable cooking behaviour to select the appropriate DfSB strategy.


DESIGN PROCESS | DISCOVER
10
Analyse if there are regulations or laws that impose DfSB strategies in the sector.
11
When redesigning products, analyse if the current artefact already features DfSB interventions and evaluate the potential for amplifying its impact.
12
Work with a culturally diverse design team in product development for cooking products.
13
Formally integrate steps on the Design process that systematically consider DfSB.
14
Build competencies on sustainable cooking among the Design personnel by trying out diverse cooking methods.
15
Analyze the internal and external barriers for implementing of DfSB strategies.
16
Align DfSB strategies with professionals involved in product development.


DESIGN PROCESS | DEFINE
17
Define if the behaviour change required is occasional or involves a permanent change of habits.
18
Identify the factors that influence and shape consumer decision-making.
19
Translate the perceptions about the impacts of consumption due to cooking in the early project phase.
20
Identify new social demands associated with cooking that can promote the inclusion of vulnerable populations.
21
Value local community culture and infrastructure through cooking choices.
22
Define the desirable behaviour to select the appropriate DfSB strategy.
23
Define the desirable cooking behaviour to select the appropriate DfSB strategy.
24
Evaluate the risks of proposing solutions restricted to regional cultural habits.
25
Disseminate good practices of sustainable cooking to users.


DESIGN PROCESS | DEVELOP
26
Develop as much as possible customized solutions on DfSB, enhancing effectiveness to individual needs and motivations.
27
Avoid to restrict the user's autonomy while using the appliance.
28
Implement solutions that motivate users to desire migrate to sustainable behaviour.
29
Make the consumption of resources visible, understandable, and accessible to the user, where/when he/she wants and on the format they want.
30
Encourage users to reflect on their consumption and the responsibility of their action during usage.
31
Stimulate users culinary learning and skills in a sustainable way, encouraging them to keep their traditions.
32
Encourage gender equity in the cooking activity.
33
Educate users about the benefits of sustainable home cooking.
34
Discourage the cooking of ultra-processed foods and foods with low nutritional value.


DESIGN PROCESS | DEVELOP
35
Promote a culinary experience that values cultural identity, local conditions, and the feeling of cooking something unique.
36
Educate the user on the benefits of local and seasonal food consumption.
37
To promote attitudinal change towards a more distributed economy and fair trade in the food sector.
38
Measure the effectiveness of the DfSB strategies applied and monitoring product field tests to identify opportunities for improvement.
39
Make clear to users the motivations for adopting DfSB strategies on product design.
40
Boosting behaviour change through the application of several DfSB strategies.
41
Prefer to apply DfSB interventions to the product that are directly perceived by the user.
42
Inform the user, in a transparent way, of the company's actions towards sustainability.
43
Document the lessons learned from the application of the DfSB interventions.



SOURCE: The author (2023).

The proposed guidelines that resulted from study were organized in order to facilitate the visualization and application by designers in the development of cooking appliances. These propositions focused on the tactical-operational level of product development, not contemplating repercussions and possibilities of use at the strategic level. Nevertheless, the potential contribution of this artifact into other stages of the design process have been pointed out by the collaborators of the industry partner, implying the possibility of expanding its scope to services, systems, and social innovation.

5 CONCLUSION

5.1 FINAL CONSIDERATIONS

This dissertation contributes new knowledge and tools to the field of Design for Sustainable Behaviour through the development of guidelines for cooking appliances based on DfSB strategies. The guidelines developed contemplate parameters for the application of interventions, contributing to the efficiency of the Design process and the development of more assertive products in the reduction of impacts for sustainability.

The study is located at the intersection of Design for Sustainable Behavior, Food Cooking, and Household Appliances. The theoretical basis extracted from the literature review, the comparative product analysis survey, the application of the workshops, as well as their analysis, evaluation, and reflection made it possible to achieve the result of the guidelines development.

The outcomes produced were compiled and presented through 59 guidelines for the development of cooking products, supported by the strategies of Design for Sustainable Behavior. They were categorized into 3 groups according to the Double Diamond design process: discover, define, and develop. The "discover" category comprised 21 guidelines, while the "define" category covered 11 and the "develop" category 27.

Given the above, the results answer this dissertation's central question: How to guide innovation on major cooking appliances during the design process toward sustainable behavior? Considering the secondary research objectives, the results satisfied all of them: (A) To characterize the concept of Sustainable Cooking, its environmental impacts on the Brazilian context and the general habits that are associated with more sustainable habits on this activity; (B) To explore the implications of DfSB in terms of product innovation on a real-world industrial context; (C) To identify the key competencies required by design professionals interested on applying DfSB on household appliances.

Therefore, it is concluded that through the final proposition of the guidelines, the main objective, which was to propose Design for Sustainable Behavior guidelines to assist designers in developing home cooking appliances, was achieved.

5.2 RESEARCH METHOD CONSIDERATIONS

The combination of the theoretical review and Design Science Research (DSR) was effective for the development and understanding of this study in order to achieve the proposed objectives.

The literature review contributed to the theoretical base and the guidelines' development. Through the theoretical base, the knowledge of the researcher and the professionals involved in this work was broadened and allowed both parties to understand the evidence, limits, gaps, and opportunities for innovation in cooking products. This phase also contributed to understanding behaviour, habit, behaviour change, taxonomies of sustainable behaviours, and Design strategies to encourage more sustainable behaviours.

The survey, applied in the initial phase of the DSR method, allowed an understanding of the state of the art of applying DfSB strategies in cooking products to be reached, also contributing to the proposition of guidelines based on the results found.

The co-creative workshops counted on the strong engagement and collaboration of the professionals. The company showed great interest in adopting the guidelines for its product development practice. This support was fundamental for the development and evaluation of the artifact. However, one of the difficulties encountered in the guidelines' development was the complexity and depth required, affected by the time of the workshops. Future studies should consider methods that contemplate a broader space for discussion and knowledge assimilation to expand or improve the established guidelines.

The pandemic context of COVID-19 mainly affected the first year of the research, making it impossible to conduct field research in loco. The second year, in which the workshops took place, demonstrated that the direct contact with the professionals, in a presential mode, allowed for a more in-depth discussion, more creative results, and a greater exchange of experiences.

Even in the hybrid context with participants in a remote room, it was possible to achieve the objectives proposed due to the fact that the participants were comfortable with the hybrid workplace in the company. However, it can be challenging in a context in which the attendees are not used to using remote collaboration tools. In this sense, it is emphasized the importance of designers adapting promptly to unexpected contexts without disregarding the relevance of interpersonal relationships in the contribution of the projects.

One of the fundamental aspects of effectively applying DfSB strategies is understanding the cultural context. Hence, the designer must search for the necessary information to discern and understand the cultural influences that impact the users' behavior and decision-making.

However, in addition to the designer's competencies and applying DfSB strategies in a practical context, companies must promote a culture of sustainability. This promotion occurs through actions, stimuli, development of competencies, and openness to sharing practical and scientific knowledge with academia. The application of the methods and the results obtained in this research were also possible due to the culture toward sustainability within the partner company, its support for the field research, and its interest in applying the results.

5.3 SUGGESTIONS FOR FUTURE STUDIES

From the results obtained and the barriers faced, it is possible to point out future work intending to deepen and expand the knowledge arising from this dissertation.

Considering that the guidelines are directly related to product development, it is possible to apply them in practical terms and evaluate the results of this application. There is the possibility of expanding the results of the guidelines to other categories of appliances that consider different consumer habits and cultures.

The implications of the use of the guidelines can be explored through a model for evaluating their effectiveness. Also important is monitoring desirable behaviors during use that can be evaluated in product field tests or laboratories with users' participation.

The adoption of the guidelines by the appliance industry can enhance the responsibility of manufacturers in the commitment to more sustainable practices, implying new regulations that favor the industry and the companies committed to influencing behaviors towards sustainability.

Finally, the guidelines can be applied and tested in other contexts, not only in industrial sectors but also in educational and international environments, taking into account different cultural contexts.

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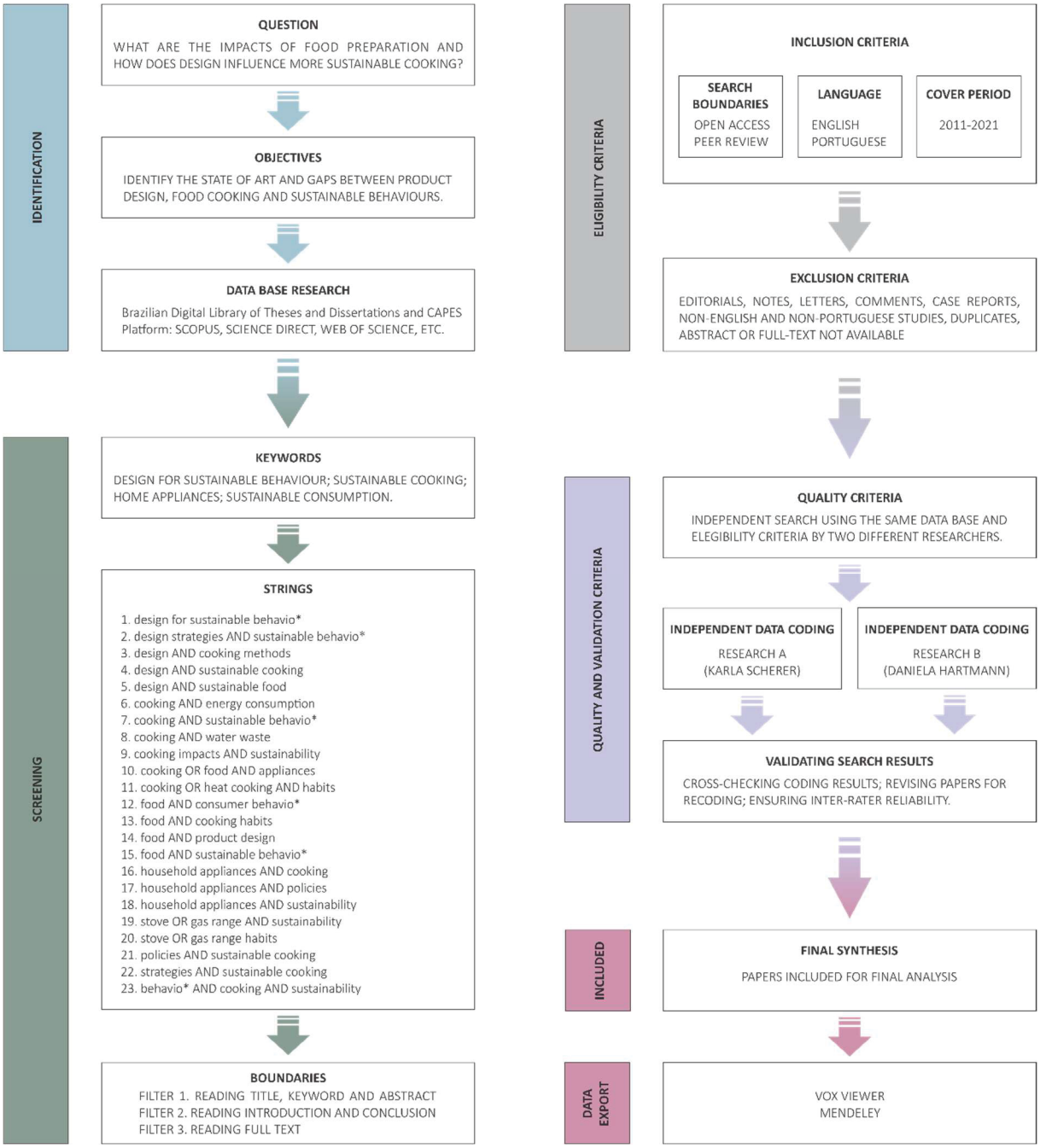
APPENDIX I – SYSTEMATIC LITERATURE REVIEW PROTOCOL



APPENDIX II – A-GUIDELINES

A-GUIDELINES OBTAINED FROM LITERATURE REVIEW ANALYSIS

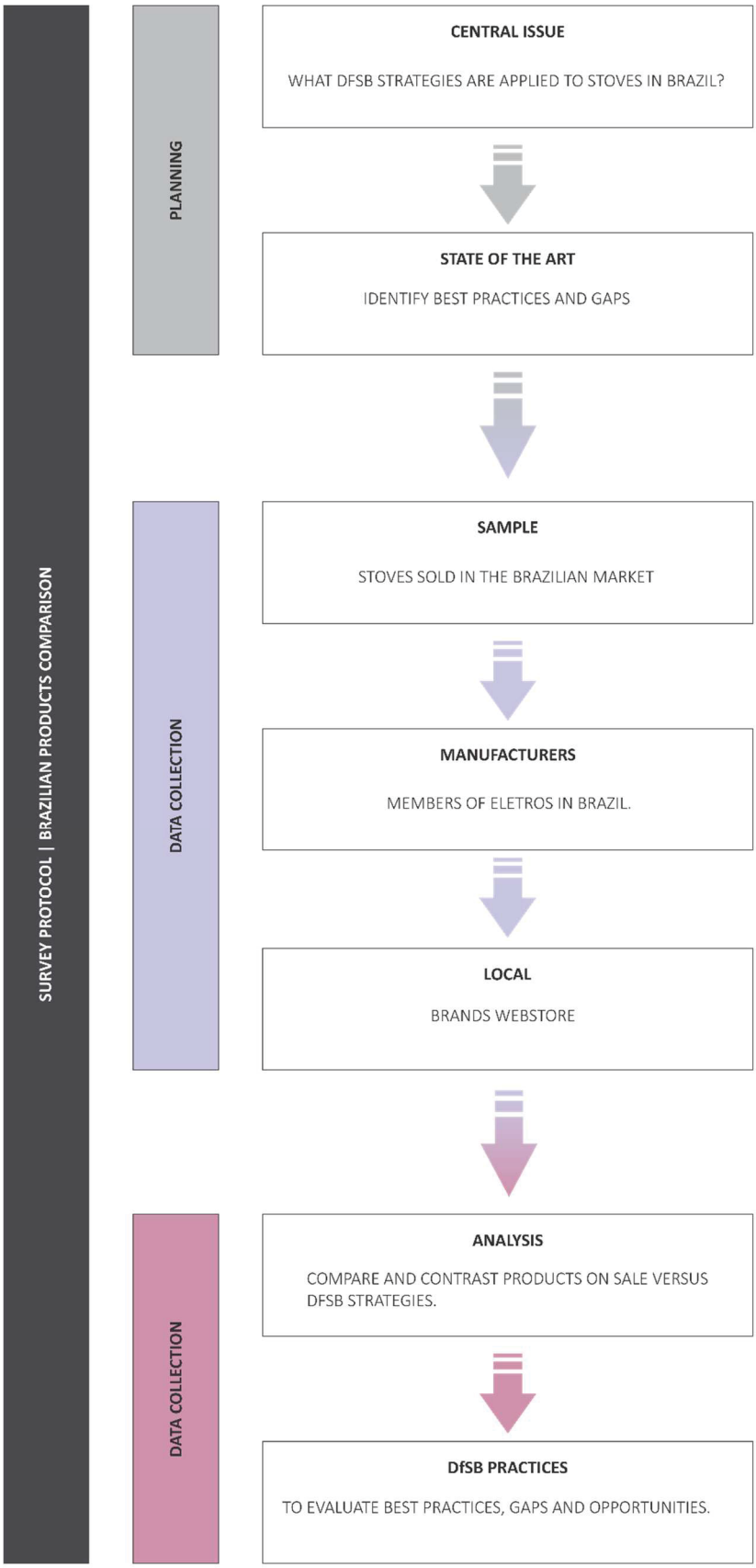
Nº	A-GUIDELINES	SOURCE	DESIGN STEP
A1	Influence behavioral changes with a focus on satisfying the user's needs and desires in harmony with the pillars of sustainability.	SCHERER, 2023; VEZZOLI et al., 2018.	DISCOVER
A2	Increase the knowledge about the user's experiences, motivations, and needs.	REDSTRÖM, 2006.	DISCOVER
A3	Understand the user's behavior.	WEVER, 2012; MEDEIROS et al., 2018.	DISCOVER
A4	Learn about users' mental models.	WEVER, 2012; MEDEIROS et al., 2018.	DISCOVER
A5	Understand sociological and psychological aspects that affect the user.	SANTOS et al., 2018.	DISCOVER
A6	Understand consumption habits.	TANG & BHAMRA, 2012.	DISCOVER
A7	Understand aspects of globalization, local cultures, and socio-environmental impacts.	SANTOS et al., 2018.	DISCOVER
A8	Define if the behaviour change is occasional or involves a change of habits.	JACKSON, 2005.	DEFINE
A9	Identify the factors that influence and shape consumer decision-making.	BHAMRA & TANG, 2008.	DEFINE
A10	Translate the perceptions of use in the early project phase.	WEVER, 2012; MEDEIROS et al., 2018.	DEFINE
A11	Identify new social demands that promote the inclusion of vulnerable populations.	SAMPAIO et al., 2018.	DEFINE
A12	Promote local community empowerment.	SANTOS et al., 2018	DEFINE
A13	Develop solutions in an ethical, empathetic, and responsible manner.	SANTOS et al., 2018.	DEVELOP
A14	Make it easy for users to adopt sustainable behaviours.	NIEDDERER et al. 2014; BHAMRA et al., 2011.	DEVELOP
A15	Impose difficulties for users to perform unsustainable behaviours.	NIEDDERER et al. 2014; BHAMRA et al., 2011.	DEVELOP

Nº	A-GUIDELINES	SOURCE	DESIGN STEP
A16	Make users want to adopt sustainable behaviour.	NIEDDERER et al. 2014.	DEVELOP
A17	Avoid that user prefers to perform in an unsustainable way.	NIEDDERER et al. 2014.	DEVELOP
A18	Educate the user about the impacts of unsustainable consumption on cooking.	FRANKOWSKA et al., 2020.	DEVELOP
A19	Make the consumption of resources visible, understandable, and accessible to the user.	BHAMRA et al., 2011.	DEVELOP
A20	Encourage users to reflect on the resources consumed during usage.	BHAMRA et al., 2011.	DEVELOP
A21	Encourage users to reflect on the responsibility of their actions for sustainability during usage.	BHAMRA et al., 2011.	DEVELOP
A22	Encourage users to adopt clean energy sources for cooking.	MAES AND VERBIST, 2012.	DEVELOP
A23	Stimulate the user's culinary learning and skills in a sustainable way.	KATZ & WEAVER, 2002; HART, 2019.	DEVELOP
A24	Inspire users to explore more sustainable usage practices.	BHAMRA et al., 2011.	DEVELOP
A25	Encourage gender equity in the cooking activity.	GALLUP, 2021.	DEVELOP
A26	Educate users about the benefits of home cooking.	KOLODINSKY & GOLDSTEIN, 2011; POLLAN, 2013; PLESSZ & ÉTILÉ, 2019; SARDA et al., 2022; LAVELLE et al., 2016; HART, 2019; GATLEY et al., 2014; KRAMER et al., 2012; SIMMONS & CHAPMAN, 2012; WOLFSON & BLEICH, 2015.	DEVELOP
A27	Discourage the cooking of ultra-processed foods and foods with low nutritional value.	SMITH & POPKIN, 2013; THARREY et al., 2020; STITT, JEPSON, PAULSON-BOX, & PRISK, 1996; BLYTHMAN, 2013.	DEVELOP
A28	Promote a culinary experience that values cultural identity, local conditions, and the feeling of cooking something unique.	LÉVI-STRAUSS, 1968; MACIEL, 2004; FREYRE, 2006; BRILLAT-SAVARIN, 2009; CASCUDO, 2016.	DEVELOP
A29	Encourage the user to keep their traditions and skills in a sustainable way.	CARAHER & LANG, 1999.	DEVELOP
A30	Educate the user on the benefits of local and seasonal food consumption.	ANDRÉ, 2013; GATLEY et al., 2014.	DEVELOP

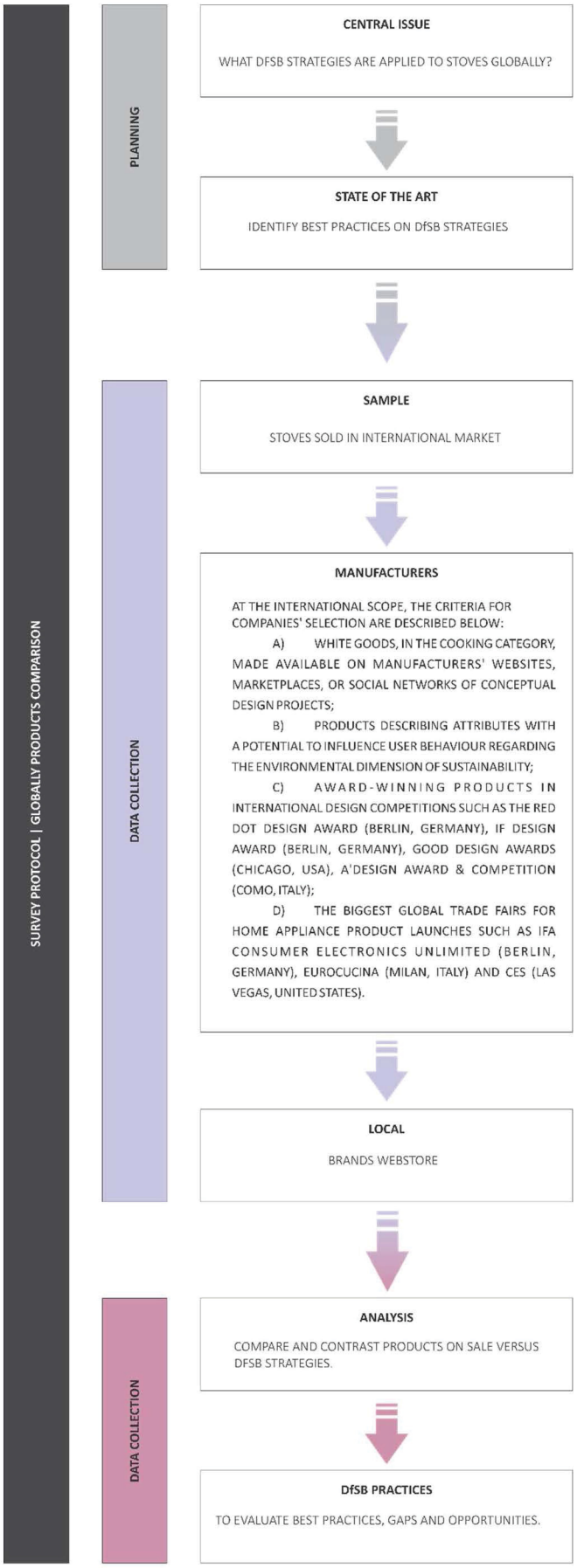
Nº	A-GUIDELINES	SOURCE	DESIGN STEP
A31	To promote attitudinal change towards decentralisation of the economy and fair trade.	SANTOS et al., 2019.	DEVELOP
A32	Measure the effectiveness of the applied DfSB strategies.	LIDMAN & RESTRÖM, 2011; NIEDDERER et al., 2014; WEVER, 2012; MEDEIROS et al., 2018.	DEVELOP

SOURCE: THE AUTHOR (2023).

APPENDIX III – SURVEY PROTOCOL



SOURCE: The author (2022). Based on the model proposed by Leibfried & McNair (1994).



SOURCE: The author (2022). Based on the model proposed by Leibfried & McNair (1994).

APPENDIX IV – B-GUIDELINES

B-Guidelines obtained from Product Benchmarking analysis

Nº	B-GUIDELINES	SOURCE	DESIGN STEP
B1	Understand the level of consumer maturity for sustainability.	SURVEY	DISCOVER
B2	Define the desirable behaviour to select the appropriate DfSB strategy.	SURVEY	DEFINE
B3	Make clear to users the motivations of product design for sustainability.	SURVEY	DEVELOP
B4	Make users aware of the impacts resulting from the product's use.	SURVEY	DEVELOP
B5	Broaden users' understanding of the responsibility of their individual actions and correspondent impacts on sustainability.	SURVEY	DEVELOP
B6	Engage users in the behavioural change process.	SURVEY	DEVELOP
B7	Enhance sustainable behaviours by using DfSB strategies.	SURVEY	DEVELOP
B8	Prefer to apply DfSB interventions to the product areas that interact directly with the user.	SURVEY	DEVELOP
B9	Propose a personalised approach to increase user identification and engagement.	SURVEY	DEVELOP
B10	Avoid restricting the user's autonomy while using the device.	SURVEY	DEVELOP
B11	Inform the user, in a transparent way, of the company's actions towards sustainability.	SURVEY	DEVELOP
B12	Evaluate and test how effective the solution is for sustainability.	SURVEY	DEVELOP

SOURCE: The author (2023).

APPENDIX V – WORKSHOP 1 PROTOCOL

WORKSHOP 1 | PROTOCOL – DESIGN TALKS ON DESIGN FOR SUSTAINABLE BEHAVIOUR

Facilitator

Karla Scherer (Master student in Design - UFPR)

Support

Daniela Hartmann (Scientific Initiation researcher in Design – UFPR)

Felipe Westphalen (Undergraduate student in Design – UFPR)

Goal

To apply academic knowledge in DfSB to an industrial context, using a case study-based approach, to explore the application of DfSB strategies.

For whom it is addressed

Electrolux Design Team. The number of people corresponds to the number of company professionals.

Room organisation (Electrolux)

1:00 – 1:30pm Preparation of the Electrolux presentation room where the event will be held. Check audiovisual, HDMI cable, functioning of Microsoft Teams (for remote participants), and Miro link access.

Reception of guests

1:30 – 2:00pm Reception of the guests.

Materials:

- 01 Board which will guide the task;
- 06 Cards of consumption and cultural habits;
- 05 post-it colors to use on the board.
- pens for taking notes

Workshop opening

2:00 – 2:05 Presentation of the research team. Online guests can ask questions and leave them in the chat room where Felipe and Daniela will be chatting. For questions not answered during the presentation, please send an e-mail to: karlascherer@ufpr.br.

2:05 – 2:35pm Workshop start:

- Presentation of the goal;
- Presentation of DfSB principles, strategies, fields and cases;

DfSB Gym

2:45 – 2:50pm Explanation of the workshop's goal and how round 1 works.

Round 1

2:50 – 2:58pm Participants will have 8 minutes to propose a solution according to the suggested strategy for the indicated persona and her needs.

Round 1 Voting

2:58 – 3:00pm Select the post-it with the best idea and choose the star emoji in the options bar to count the vote.

Round 2

15:00 – 15:08 Participants will have 8 minutes to propose a solution according to the suggested strategy for the indicated persona and her needs.

Round 2 Voting

15:08 – 15:10 Select the post-it with the best idea and choose the star emoji in the options bar to count the vote.

Round 3

15:10 – 15:18 Participants will have 8 minutes to propose a solution according to the suggested strategy for the indicated persona and her needs.

Round 3 Voting

15:18 – 15:20 Select the post-it with the best idea and choose the star emoji in the options bar to count the vote.

Discussion

3:20 – 3:50pm

Closing

3:50 – 4:00pm

APPENDIX VI – C-GUIDELINES

C-Guidelines obtained from Workshop 1 analysis

Nº	C-GUIDELINES	SOURCE	DESIGN STEP
C1	Understand levels of the behavioural change and DfSB strategies.	WS1	DISCOVER
C2	Understand behavioural theories that support individual change, contextual change or both.	WS1	DISCOVER
C3	Understanding the differences between behaviour and habitus.	WS1	DISCOVER
C4	Knowing field applications of the DfSB approach.	WS1	DISCOVER
C5	Making DfSB knowledge accessible to the company's designers.	WS1	DEFINE
C6	Consider the designer's previous skills in influencing behaviour.	WS1	DEFINE
C7	Define if the focus of change is on the individual, on the wider context, or both.	WS1	DEFINE
C8	Consider the consumer's maturity level on sustainability.	WS1	DEFINE
C9	Consider the user's interest in adopting new behaviours.	WS1	DEFINE
C10	Understand which energy sources are suitable for the device's most sustainable use.	WS1	DEFINE
C11	Aligning prioritized DfSB strategies with professionals involved in product development.	WS1	DEFINE
C12	Encourage user awareness of the impacts of use on sustainability.	WS1	DEVELOP
C13	Boosting behaviour change through the plural application of DfSB strategies.	WS1	DEVELOP
C14	Educate users on the carbon footprint produced by the selected cooking method.	WS1	DEVELOP

Nº	C-GUIDELINES	SOURCE	DESIGN STEP
C15	Guide the user in choosing the right pan size for the oven burner.	WS1	DEVELOP
C16	Inform users about the appropriate water quantity for their chosen meal and cooking method.	WS1	DEVELOP
C17	Consider the re-use of residual heat.	WS1	DEVELOP
C18	Test the performance of the artifact from a combination of more sustainable cooking methods and fuel sources.	WS1	DEVELOP
C19	Analyze the barriers that may invalidate the implementation of DfSB strategies.	WS1	DEVELOP
C20	Evaluate the undesirable behaviours that may be triggered by the DfSB strategies selected.	WS1	DEVELOP
C21	Document the lessons learned from the application of the DfSB interventions.	WS1	DEVELOP

SOURCE: The author (2023).

APPENDIX VII – WORKSHOP 2 PROTOCOL

WORKSHOP 2 | PROTOCOL – CO-CREATION OF GUIDELINES FOR DESIGN SUSTAINABLE COOKING PRODUCTS

Facilitator

Karla Scherer (Master student in Design - UFPR / Loughborough University)

Goal

Based on the strategies of Design for Sustainable Behaviour, co-create proposals for guidelines for designing sustainable cooking products.

For whom it is addressed

ng in the cooker and cooktop development. The number of people corresponds to the number of company professionals involved in the development of these products.

Room organisation (Electrolux)

1:00 – 1:30pm Preparation of the Electrolux workshop room where the event will be held.

Reception of guests

1:30 – 2:00pm Reception of the guests.

Materials:

- 01 Board which will guide the task;
- 06 Cards of consumption and cultural habits;
- 05 post-it colors to use on the board.
- pens for taking notes

Workshop opening

2:00 – 2:20pm Workshop start:

- Presentation of the goal which is to propose ideas and recommendations for the creation of guidelines;
- Definition of the Sustainable Cooking concept;
- The impact of cultural and consumption habits to influence sustainable cooking behaviour.

Ideas generation towards the creation of guidelines for design sustainable cooking products

2:20 – 2:30pm Delivery of the materials and dynamic orientation.

2:30 – 2:40pm First round of ideas.

2:40 – 2:50pm Discussion of first results (mirror-feedback).

2:50 – 3:00pm Second round of ideas.

3:00 – 3:10pm Discussion of the second results (mirror-feedback).

3:10 – 3:20pm Third round of ideas.

3:20 – 3:30pm Discussion of the third results (mirror-feedback)

3:30 – 3:50pm Final considerations

3:50 – 4:00pm Closing

APPENDIX VIII – D-GUIDELINES

D-Guidelines obtained from Workshop 2 analysis

Nº	D-GUIDELINES	SOURCE	DESIGN STEP
D1	Analyse if the briefing clearly proposes the application of DfSB strategies in the product.	WS2	DISCOVER
D2	Analyse wheather DfSB strategies are required by the company, industry sector, or government institutions.	WS2	DISCOVER
D3	When redesigning products, analyse if the current artefact already features DfSB interventions and evaluate the potential for amplifying it.	WS2	DISCOVER
D4	Work with a culturally diverse design team in cooking product development.	WS2	DISCOVER
D5	Investigate gaps in the design process that may provide opportunities for sustainable change.	WS2	DISCOVER
D6	Know the impacts on sustainability produced during the cooking activity.	WS2	DISCOVER
D7	Conduct research to understand consumer usage habits.	WS2	DISCOVER
D8	Understand the consumption and impact of all the resources involved in cooking.	WS2	DISCOVER
D9	Improve knowledge about users and the context in which the product is used.	WS2	DISCOVER
D10	Explore the cultural cooking habits in the regions where the product will be commercialized.	WS2	DISCOVER
D11	Conduct ethnographic research to understand social phenomena that affect cultural habits and user behaviour.	WS2	DISCOVER
D12	Know and test sustainable cooking methods.	WS2	DISCOVER
D13	Analyse if the briefing clearly proposes the application of DfSB strategies in the product.	WS2	DISCOVER
D14	Analyse wheather DfSB strategies are required by the company, industry sector, or government institutions.	WS2	DISCOVER
D15	When redesigning products, analyse if the current artefact already features DfSB interventions and evaluate the potential for amplifying it.	WS2	DEFINE
D16	Work with a culturally diverse design team in cooking product development.	WS2	DEFINE
D17	Investigate gaps in the design process that may provide opportunities for sustainable change.	WS2	DEFINE

Nº	D-GUIDELINES	SOURCE	DESIGN STEP
D18	Know the impacts on sustainability produced during the cooking activity.	WS2	DEFINE
D19	Conduct research to understand consumer usage habits.	WS2	DEVELOP
D20	Understand the consumption and impact of all the resources involved in cooking.	WS2	DEVELOP
D21	Improve knowledge about users and the context in which the product is used.	WS2	DEVELOP
D22	Explore the cultural cooking habits in the regions where the product will be commercialized.	WS2	DEVELOP
D23	Conduct ethnographic research to understand social phenomena that affect cultural habits and user behaviour.	WS2	DEVELOP
D24	Know and test sustainable cooking methods.	WS2	DEVELOP
D25	Analyse if the briefing clearly proposes the application of DfSB strategies in the product.	WS2	DEVELOP
D26	Analyse wheather DfSB strategies are required by the company, industry sector, or government institutions.	WS2	DEVELOP
D27	When redesigning products, analyse if the current artefact already features DfSB interventions and evaluate the potential for amplifying it.	WS2	DEVELOP
D28	Work with a culturally diverse design team in cooking product development.	WS2	DEVELOP
D29	Investigate gaps in the design process that may provide opportunities for sustainable change.	WS2	DEVELOP
D30	Know the impacts on sustainability produced during the cooking activity.	WS2	DEVELOP

SOURCE: The author (2023).

APPENDIX IX – CROSS-FINDINGS

Cross-findings of preliminary guidelines

Nº	GUIDELINES	SOURCE	DESIGN STEP
A1	Influence behavioral changes with a focus on satisfying the user's needs and desires in harmony with the pillars of sustainability.	SCHERER, 2023; VEZZOLI et al., 2018.	DISCOVER
A2	Increase the knowledge about the user's experiences, motivations, and needs.	REDSTRÖM, 2006.	DISCOVER
A3	Understand the user's behavior.	WEVER, 2012; MEDEIROS et al., 2018.	DISCOVER
A4	Learn about users' mental models.	WEVER, 2012; MEDEIROS et al., 2018.	DISCOVER
A5	Understand sociological and psychological aspects that affect the user.	SANTOS et al., 2018.	DISCOVER
A6	Understand consumption habits.	TANG & BHAMRA, 2012.	DISCOVER
A7	Understand aspects of globalization, local cultures, and socio-environmental impacts.	SANTOS et al., 2018.	DISCOVER
B1	Understand the user maturity level for sustainability.	SURVEY	DISCOVER
C1	Understand levels of the behavioural change and DfSB strategies.	WS1	DISCOVER
C2	Understand behavioural theories that support individual change, contextual change or both.	WS1	DISCOVER
C3	Understand the differences between behaviour and habitus.	WS1	DISCOVER
C4	Know the fields of the DfSB approach.	WS1	DISCOVER
D1	Analyse if the briefing proposes the application of DfSB strategies in the product.	WS2	DISCOVER
D2	Analyse if DfSB strategies are required by the company, industry sector, or government institutions.	WS2	DISCOVER
D3	When redesigning products, analyse if the current artefact features DfSB interventions and evaluate the potential for amplifying the strategies.	WS2	DISCOVER

Nº	GUIDELINES	SOURCE	DESIGN STEP
D4	Work with a culturally diverse design team in cooking product development.	WS2	DISCOVER
D5	Investigate gaps in the design process that may provide opportunities for sustainable change.	WS2	DISCOVER
D6	Know the impacts on sustainability produced during the cooking activity.	WS2	DISCOVER
D7	Conduct research to understand consumer usage habits.	WS2	DISCOVER
D8	Understand the consumption and impact of all the resources involved in cooking.	WS2	DISCOVER
D9	Improve knowledge about users and the context in which the product is used.	WS2	DISCOVER
D10	Explore the cultural cooking habits in the regions where the product will be commercialized.	WS2	DISCOVER
D11	Conduct ethnographic research to understand social phenomena that affect cultural habits and user behaviour.	WS2	DISCOVER
D12	Know and test sustainable cooking methods.	WS2	DISCOVER
D13	Identify which sustainable foods and techniques can be stimulated to encourage user behaviour change.	WS2	DISCOVER
D14	Map and analyse the user decisions that impact the practice of cooking in the user journey.	WS2	DISCOVER
A8	Define if the behaviour change is occasional or involves a change of habits.	JACKSON, 2005.	DEFINE
A9	Identify the factors that influence and shape consumer decision-making.	BHAMRA & TANG, 2008.	DEFINE
A10	Translate the perceptions of use in the early project phase.	WEVER, 2012; MEDEIROS et al., 2018.	DEFINE
A11	Identify new social demands that promote the inclusion of vulnerable populations.	SAMPAIO et al., 2018.	DEFINE
A12	Promote local community empowerment.	SANTOS et al., 2018	DEFINE
B2	Define the desirable behaviour to select the appropriate DfSB strategy.	SURVEY	DEFINE

Nº	GUIDELINES	SOURCE	DESIGN STEP
C5	Making DfSB knowledge accessible to the company's designers.	WS1	DEFINE
C6	Consider the designer's skills in influencing behaviour.	WS1	DEFINE
C7	Define if the focus of change is on the individual, contextual, or both.	WS1	DEFINE
C8	Identify the consumer's maturity level on sustainability.	WS1	DEFINE
C9	Consider the user's interest in adopting new behaviours.	WS1	DEFINE
C10	Understand which energy sources are suitable for the device's most sustainable use.	WS1	DEFINE
C11	Align DfSB strategies with professionals involved in product development.	WS1	DEFINE
D15	Evaluate the risks of proposing solutions restricted to regional cultural habits.	WS2	DEFINE
D16	Understand the risks of ignoring cultural and behavioural aspects of the user in product development.	WS2	DEFINE
D17	Investigate and use technologies capable of converting information on cooking habits into data.	WS2	DEFINE
D18	Disseminate good practices of sustainable cooking.	WS2	DEFINE
A13	Develop solutions in an ethical, empathetic, and responsible manner.	SANTOS et al., 2018.	DEVELOP
A14	Make it easy for users to adopt sustainable behaviours.	NIEDDERER et al. 2014; BHAMRA et al., 2011.	DEVELOP
A15	Impose difficulties for users to perform unsustainable behaviours.	NIEDDERER et al. 2014; BHAMRA et al., 2011.	DEVELOP
A16	Make users want to adopt sustainable behaviour.	NIEDDERER et al. 2014.	DEVELOP
A17	Avoid that user prefers to perform in an unsustainable way.	NIEDDERER et al. 2014.	DEVELOP

Nº	GUIDELINES	SOURCE	DESIGN STEP
A18	Educate the user about the impacts of unsustainable consumption on cooking.	FRANKOWSKA et al., 2020.	DEVELOP
A19	Make the consumption of resources visible, understandable, and accessible to the user.	BHAMRA et al., 2011.	DEVELOP
A20	Encourage users to reflect on the resources consumed during usage.	BHAMRA et al., 2011.	DEVELOP
A21	Encourage users to reflect on the responsibility of their actions for sustainability during usage.	BHAMRA et al., 2011.	DEVELOP
A22	Encourage users to adopt clean energy sources for cooking.	MAES AND VERBIST, 2012.	DEVELOP
A23	Stimulate the user's culinary learning and skills in a sustainable way.	KATZ & WEAVER, 2002; HART, 2019.	DEVELOP
A24	Inspire users to explore more sustainable usage practices.	BHAMRA et al., 2011.	DEVELOP
A25	Encourage gender equity in the cooking activity.	GALLUP, 2021.	DEVELOP
A26	Educate users about the benefits of home cooking.	KOLODINSKY & GOLDSTEIN, 2011; POLLAN, 2013; PLESSZ & ÉTILÉ, 2019; SARDA et al., 2022; LAVELLE et al., 2016; HART, 2019; GATLEY et al., 2014; KRAMER et al., 2012; SIMMONS & CHAPMAN, 2012; WOLFSON & BLEICH, 2015.	DEVELOP
A27	Discourage the cooking of ultra-processed foods and foods with low nutritional value.	SMITH & POPKIN, 2013; THARREY et al., 2020; STITT, JEPSON, PAULSON-BOX, & PRISK, 1996; BLYTHMAN, 2013.	DEVELOP
A28	Promote a culinary experience that values cultural identity, local conditions, and the feeling of cooking something unique.	LÉVI-STRAUSS, 1968; MACIEL, 2004; FREYRE, 2006; BRILLAT-SAVARIN, 2009; CASCUDO, 2016.	DEVELOP
A29	Encourage the user to keep their traditions and skills in a sustainable way.	CARAHER & LANG, 1999.	DEVELOP
A30	Educate the user on the benefits of local and seasonal food consumption.	ANDRÉ, 2013; GATLEY et al., 2014.	DEVELOP
A31	To promote attitudinal change towards decentralisation of the economy and fair trade.	SANTOS et al., 2019.	DEVELOP
A32	Measure the effectiveness of the DfSB strategies applied.	LIDMAN & RESTRÖM, 2011; NIEDDERER et al., 2014; WEVER, 2012; MEDEIROS et al., 2018.	DEVELOP

Nº	GUIDELINES	SOURCE	DESIGN STEP
B3	Make clear to users the motivations of product design for sustainability.	SURVEY	DEVELOP
B4	Make users aware of the impacts resulting from the product's use.	SURVEY	DEVELOP
B5	Broaden users' understanding of the responsibility of their individual actions and the direct impacts on sustainability.	SURVEY	DEVELOP
B6	Engage users in the behavioural change process.	SURVEY	DEVELOP
B7	Enhance sustainable behaviours by applying different DfSB strategies.	SURVEY	DEVELOP
B8	Prefer to apply DfSB interventions to the product that interact with the user.	SURVEY	DEVELOP
B9	Propose a personalised approach to increase user identification and engagement.	SURVEY	DEVELOP
B10	Avoid restricting the user's autonomy while using the device.	SURVEY	DEVELOP
B11	Inform the user, in a transparent way, of the company's actions towards sustainability.	SURVEY	DEVELOP
B12	Evaluate and test how effective the solution is for sustainability.	SURVEY	DEVELOP
C12	Encourage user awareness of the impacts of use for sustainability.	WS1	DEVELOP
C13	Boosting behaviour change through the plural application of DfSB strategies.	WS1	DEVELOP
C14	Educate users on the carbon footprint produced by the cooking method chosen.	WS1	DEVELOP
C15	Guide the user in choosing the right pan size for the burner powers.	WS1	DEVELOP
C16	Make accessible to users the appropriate water measurements for their chosen meal and cooking method.	WS1	DEVELOP
C17	Consider residual heat use.	WS1	DEVELOP

Nº	GUIDELINES	SOURCE	DESIGN STEP
C18	Test the performance of the artifact from a combination of more sustainable cooking methods and fuel sources.	WS1	DEVELOP
C19	Analyze the barriers that may invalidate the implementation of DfSB strategies.	WS1	DEVELOP
C20	Evaluate the undesirable behaviours that may be triggered by the DfSB strategies selected.	WS1	DEVELOP
C21	Document the lessons learned from the application of the DfSB interventions.	WS1	DEVELOP
D19	Make visible the consumption of resources during cooking practice.	WS2	DEVELOP
D20	Propose interventions that would benefit the reduction of resource consumption used during the cooking task.	WS2	DEVELOP
D21	Inform the user about the possibilities of reusing water spent during cooking.	WS2	DEVELOP
D22	Educate users on clean energy usage that supports the sustainable use of the product.	WS2	DEVELOP
D23	Educate the user on cooking methods and techniques appropriate to the sustainable use of the product.	WS2	DEVELOP
D24	Educate the consumer on more sustainable and responsible decisions when choosing food.	WS2	DEVELOP
D25	Value cultural and local aspects in the user's experience with the product.	WS2	DEVELOP
D26	Customise the artifact to broaden the scope of sustainable habits.	WS2	DEVELOP
D27	Propose solutions aligned with the company's sustainable strategy and the local context of product use.	WS2	DEVELOP
D28	Avoid providing excessive or unnecessary information to the consumer while using the product.	WS2	DEVELOP
D29	Evaluate the impacts for sustainability in solutions targeting more economical or faster cooking.	WS2	DEVELOP
D30	Monitor product field tests to identify gaps and opportunities for improvement in the use phase.	WS2	DEVELOP

SOURCE: The author (2023).

APPENDIX X – EVALUATION OF THE GUIDELINES VERSION 1.0

Design for Sustainable Behavior - food preparation Guidelines Evaluation

Preencher essas duas planilhas

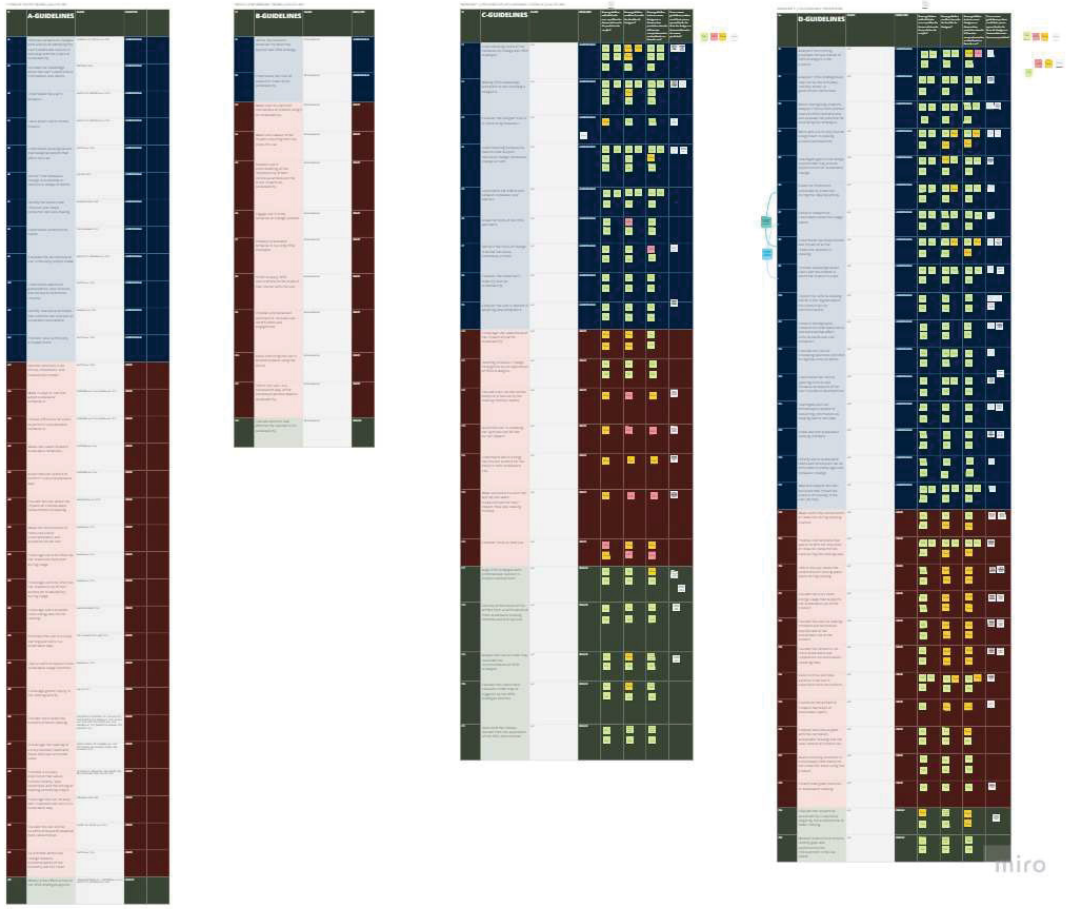
Instruções

Verificar se as diretrizes, principalmente as **C-guidelines** e **D-guidelines:**

1. **estão alinhadas com a prática de desenvolvimento de produtos de cocção,**
2. **auxiliam a tomada de decisão do designer e,**
3. **instruem novos designers a desenvolver produtos visando influenciar comportamentos sustentáveis na fase de uso.**

Responder:
Como essas guidelines podem contribuir para o aprendizado do time de design e o desenvolvimento de novos produtos?

Por favor, mantenham seus nomes nos post-its para facilitar.



ANNEX I – CONSENT FORM

MINISTÉRIO DA EDUCAÇÃO
UNIVERSIDADE FEDERAL DO PARANÁ
Setor de Artes, Comunicação e Design
Programa de Pós-Graduação em Design

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO (TCLE)

Declaro, por meio deste termo, que concordei em ser entrevistado(a) de forma voluntária por Aguinaldo dos Santos, Karla Mayke Círico Scherer Schlichting e Daniela Milena Hartmann com o objetivo de escrever um possível livro, artigos acadêmicos e outras publicações, excertos da referida pesquisa, desenvolvidos no Programa de Pós-Graduação em Design da Universidade Federal do Paraná. Fui informado(a), ainda, de que a pesquisa é orientada pelo Prof. Dr. Aguinaldo dos Santos, a quem poderei contatar/consultar a qualquer momento que julgar necessário por meio do e-mail asantos@ufpr.br e/ou do telefone (41) 3360-5313. Afirmo que aceitei participar por minha própria vontade. Fui informado(a) do objetivo da pesquisa, que, em linhas gerais, trata de um “modelo de estratégias de design para o comportamento sustentável aplicado a eletrodomésticos de cocção”. Fui também esclarecido(a) de que as eventuais divulgações desta pesquisa manterão o anonimato dos voluntários sendo assegurado o sigilo sobre sua participação. Fui ainda informado(a) que posso me retirar desse(a) estudo/pesquisa/programa a qualquer momento, sem prejuízo para meu acompanhamento ou sofrer quaisquer sanções ou constrangimentos.

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Nome completo e RG

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Assinatura