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DESIGN FOR SUSTAINABLE USE USING PRINCIPLES OF BEHAVIOUR CHANGE

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Abstract

This chapter briefly sketches and visualizes how Design for Sustainable Behaviour (DfSB) has developed into an interdisciplinary research field within the past 10 years. Research within this field has resulted in an ever growing database of case studies that investigate an increasing number of behaviours and practice. These case studies differ considerably in terms of case study setup, user centred methods applied, target problems addressed, design methodology used, proposed solutions and tests whether the solutions have led to (sustainable) behaviour change. Few, if any cases follow a complete design process, including problem finding, user research, analysis, ideation, conceptualization and testing. In this chapter, one major (on spatial heating using woodstoves) and two smaller (on dishwashing and sustainable sleeping) projects illustrate how using Principles of Behaviour Change – an approach developed at the Norwegian University of Science and Technology (NTNU) – can inform such a complete process. Though the case studies may inspire how to do a design project aimed at developing interventions to create sustainable behaviour, existing insights by no means provide a final answer how to approach these and similar research questions. The chapter concludes with some insights into how the field could develop further.

Keywords: Design for Sustainable Behaviour, design for sustainability, case studies, use phase, environmental improvement

Introduction: an increasing focus on the use phase

The first formal decade of ecodesign research, which spans approximately 1995 to 2005, saw relatively little attention to the use phase of products, and thus for the human and social aspects of sustainable product design. Common ecodesign strategies focused mainly on various Design for X (DfX) approaches, such as design for disassembly, recycling and remanufacturing, and on various material applications. Strategies related to usage had of course been considered from the early days of ecodesign, but most of these strategies were likewise based on indirect material and end-of-life considerations (Boks and McAloone, 2009); life time extension, for example, appealed to postponing the end-of-life stage, and avoiding the need for further material use.

Reduction of energy use focused on using technologies requiring less energy consumption, and thus increasing energy efficiency that way.

It was not uncommon to state that researchers and designers used a lifecycle perspective, but in reality, they contributed with 'end-of-lifecycle' solutions; focusing on the means to consumption (the product) instead of the practices involved in consumption itself (use). Research into sustainable consumption has traditionally had relatively little connection to sustainable design at the product level – in terms of research community; these topics traditionally attracted interest from scholars with distinctly different backgrounds and academic perspectives to product designers. Academic research in the sustainable product design domain has often been carried out in the design engineering tradition, usually with limited intent to make truly interdisciplinary connections, such as building or extending scientific theory in, from, with or for, other scientific domains including the social sciences, natural sciences or management sciences, for example. A lot has changed in the past decade, however. Nowadays, many scholars see the potential that design research offers to transdisciplinary perspectives into the development of sustainable solutions.

The rapidly emerging field of Design for Sustainable Behaviour (DfSB), which serves as an example of a transdisciplinary enquiry, investigates, at various levels, how to influence the sustainability impact of consumers' activities, by studying their behaviours and practices, developed over time and in space. As a result, we have seen an academic network develop, which organizes international workshops and other forms of scholarly cooperation, several dedicated special issues of acknowledged scientific journals, as well as doctoral dissertations devoted to this theme. Figure 21.1 visualizes the (arguably) most significant academic events related to the development of DfSB as a field of academic interest. It should be noted that the figure represents a very Northern European perspective, which the authors choose to justify by the fact that the bulk of DfSB literature originates from a limited number of northern European universities. Adjacent fields, such as sustainable human–computer interaction (HCI), critical design and persuasive technology focus on similar research questions but do not affiliate themselves with DfSB.

Case studies

DfSB literature provides a rapidly growing database of case studies investigating an increasing number of behaviours. Daae and Boks (2015a) provide a large overview of 27 case studies that have focused on attempts to design products that reduce the environmental impact of using them. These case studies were primarily taken from DfSB literature and are categorized according to the type of product that was focused on, the targeted behaviour change, the way the case studies were set up, the design challenge found, the proposed solutions, the methods used for testing and the results achieved. Such an overview serves the purpose of providing an illustration of the diversity and magnitude of the existing studies. An analysis of the overview suggests that case studies are polarized in their approach, and either explore the target problem or test the effectiveness of potential solutions. Very few studies report an entire process, from the identification and investigation of the behaviour to the evaluation of possible ways of improving it. Even fewer calculate or predict the potential effectiveness of the proposed solutions.

Partially in response to this observed lack of case studies, a project was carried out at the Norwegian University of Science and Technology to apply an entire DfSB process, including all aspects that other studies so far only partially covered, including prototype building and testing of environmental effects of changed behaviour; the latter being one of

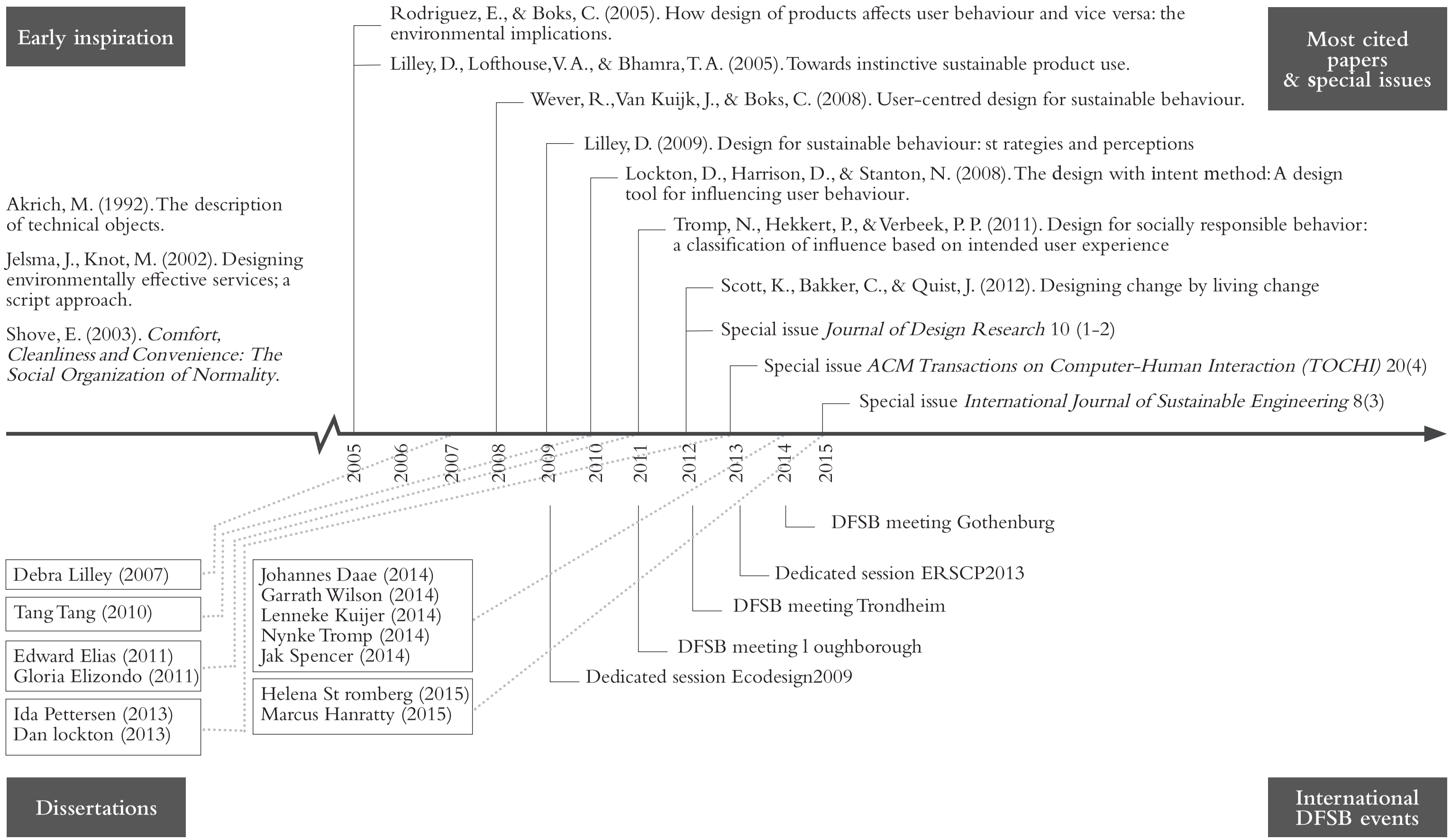


Figure 21.1 Timeline for the development of Design for Sustainable Behaviour as a research field

Source: Boks et al. (2015)

the most important omissions in most DFSB studies in literature (Wilson, 2013). The goal of the study was to investigate whether an alternative design of a woodstove, informed by principles of design for behaviour change, could allow for a type of user interaction that is more in line with recommended behaviour, and whether this would result in reduced emissions. At the time of the commencement of the study, there were very few available methods, providing direct support for design projects aiming at achieving such behaviour change.

The research approach for this project was inspired by the application of a user-centred design for sustainable behaviour process, which has been proposed as a tool referred to as Principles of Behaviour Change (Zachrisson et al., 2011; Boks and Daae, 2013b). The tool, which is based on insights from behavioural psychology, aims at helping designers make informed decisions about which design principles to apply when aiming to achieve a desired behaviour change for a target group. It suggests the consideration of a variety of user centred research methods, depending on which aspects of the user may be of particular interest given the behaviour to be studied.

The core purpose of the Principles of Behaviour Change is to identify the most promising types of design principles that may positively influence user behaviour. It makes use of a landscape that allows the sorting of design principles based on two parameters: the degree of control that a product allows the user to have over his or her behaviour, and the degree of subtlety or obtrusiveness that is designed into the solution (see Figure 21.2). Previous research (Zachrisson and Boks, 2011, 2012) revealed these two dimensions to be important ways to distinguish between design principles, but a substantial amount of additional dimensions may assist distinguishing between and selecting design principles (Daae and Boks, 2014).

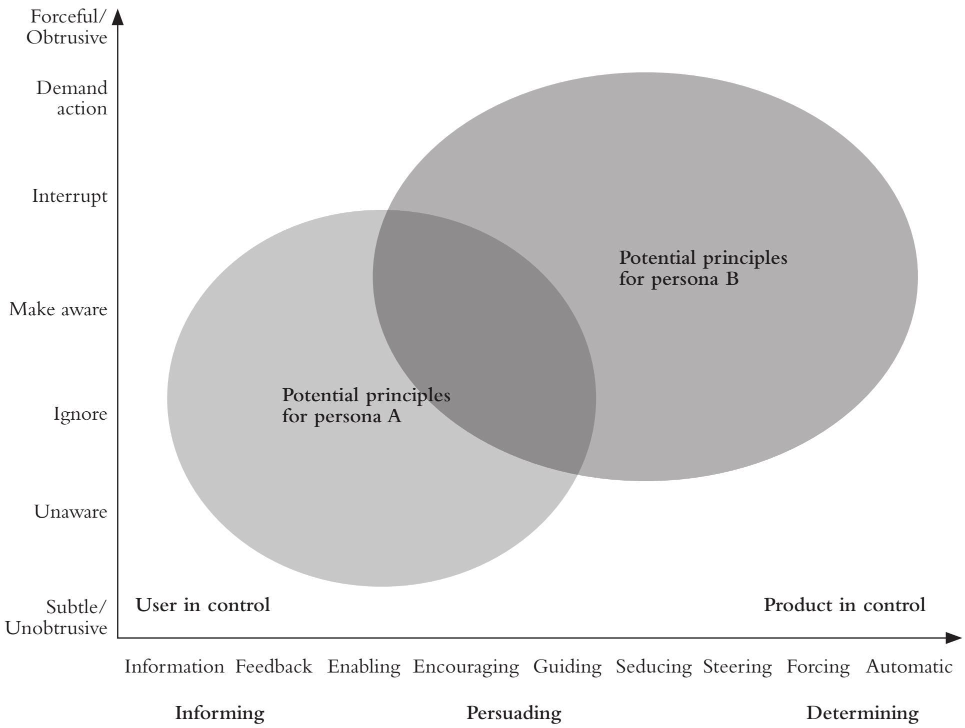


Figure 21.2 Control–obtrusiveness landscape

The idea behind this is that some design principles likely will work better for certain users in certain situations, than for others. In order to appropriately select feasible design principles for different groups of users with similar characteristics, a variety of user research methods can be used (an extensive overview of tools and their suggested application is provided by Daae and Boks, 2015b). The application of the Principles for Behaviour Change is further illustrated by the wood stove study in the next section, and by two smaller case studies in the section thereafter.

Design of a DfSB solution for ineffective burning of wood in woodstoves

For countries like Norway, fine particle, carbon and dioxin emissions resulting from burning firewood in woodstoves represent a significant environmental impact, because most households use woodstoves as a heating source. The majority of environmental impacts during the entire lifecycle of a woodstove occur during the use phase, in particular during start-up and the end phase of the burning process (Ozil et al., 2011). Emissions depend not only on the type and condition of woodstove and firewood, but also on user interaction with the stove (Haakonsen and Kvingedal, 2001; Karlsvik and Oravainen, 2009). Air supply for most modern stoves still requires manual operation by the end-user and can normally be regulated by two separate handles; one handle for ignition air through the bottom grate and a second handle to regulate the air supply to the primary combustion zone for setting the desired burn rate. The main combustion air controls the overall combustion intensity as given by the instantaneous burn rate at any time in the primary combustion zone. All modern stoves also apply what is called a secondary burnout zone where additional preheated air provides oxygen for gaseous hydrocarbons and particle burnout in the plume slightly above the main combustion zone. Active regulation of the ignition air is mainly required only when lighting the stove, where it should be fully open during a certain period, normally between 5 and 15 minutes, to support sufficient air until self-sustained combustion has been established, after which it is normally closed. For the remaining burnout and charcoal phase the effect can be set by adjusting the handle for the main combustion air. Many wood stove manufacturers also recommend lighting the stove with the door partly open. Lately recommendations for lighting woodstoves is to light the fire from the top, although this is not yet commonly applied.

A 2011 informal survey by consumer interest website www.DinSide.no, found that among 1,765 readers of a web-article about how to use a woodstove, only 10 per cent answered that they followed this recommendation. Based on this knowledge on how stoves and their users behave, there appears to be potential for reducing emissions by designing woodstoves that are likely to improve the way people interact with them. Therefore, at NTNU a project was initiated to investigate this potential by improving the design of the stove's user interface. The initiative was a collaboration between NTNU, SINTEF (Scandinavia's largest independent research organization), and Norwegian woodstove producer Jøtul, who contributed both with technical advice, participation in workshops and the development of prototypes for the final testing.

In the user research phase of the wood stove project, applied ethnography was used, where an approximation of real life product use was analysed to better understand why users behave the way they do, both consciously and subconsciously, based on interviews and analysis of video-recorded observations. Seventeen participants, all of whom used a woodstove on a regular basis, were recruited in the area around Oslo, where they lived in apartments, houses and semidetached houses. All participants were visited at home, video recordings were made of the participants firing up the woodstove, and semi-structured interviews addressed why and how they had done this the way they did, as well as other firewood energy and sustainability relate issues. Throughout each interview (which took on average one hour) participants were asked to maintain the fire in the woodstove, allowing for observation of adjustment of the air valves and reloading of wood, in cases where this was done. As expected from the choice of method, the user research resulted in an extensive and rich base of information. A summary was made of each interview and formed the basis of the creation of four *personas* (Miaskiewicz and Kozar, 2011); Personas descriptions that were created for this study were:

- *Persona 1*: a user who sees burning firewood as a hobby, is very knowledgeable but still eager to learn.
- *Persona 2*: a user who believes they know everything but does many things wrong.
- *Persona 3*: a user, who enjoys burning firewood but finds it difficult and is insecure, is interested in learning but does not care too much.
- *Persona 4*: a user who does not care and just wants everything to be as easy as possible.

In addition to the development of the personas, an overview was made of various recorded elements of behaviour that differ from the recommendations for optimal burning. These included burning wood that is too moist, using paper and cardboard to start the fire, kindling the fire from the bottom of the wood instead of from the top, not giving flames sufficient air when firing up, reducing the air too much while burning, closing the secondary air while leaving the primary air open and leaving the door ajar too long.

The goal for the design phase was to design a woodstove that would potentially make all four personas use it more in line with recommended behaviours, and as a result, it would be accepted by all the personas. To support this process the personas and the types of sub-optimal behaviour were used as input to idea generation, analysis and evaluation, and finally, concept development. To generate ideas, a workshop was arranged at Jøtul in May 2012 with seven participants from their product development, marketing and the technical departments. At the start of the workshop, the results from the user research and the personas were presented. The participants were then asked to brainstorm ideas for how to make people use a woodstove more in line with recommended behaviour, particularly targeting the list of sub-optimal behaviours. To keep the challenges simple the personas were given limited emphasis during the idea generation, although they were brought up from time to time to spur the generation of additional ideas. By analysing the results from the design workshop and excluding overlapping ideas, a number of distinct ideas were identified. These ideas were positioned in the control–obtrusiveness landscape, according to how much control and attention they demanded from the user (see Figure 21.3).

As suggested in the Principles of Behaviour Change guide, the next step was to identify those areas of the landscape that will potentially result in a desired behaviour change, which are acceptable or not acceptable for the different personas (Figure 21.4).

Combining results from the previous steps allowed for identification of the most suitable ideas, which were evaluated in collaboration with the design and technical experts at Jøtul on the basis of their feasibility and how easily they could be included in a product prototype. As a result, it was determined that the prototype should include a combination of some of the ideas, which also directly respond to some of the most obvious shortcomings of the vast majority of the woodstoves on the Norwegian market, where almost all the woodstoves

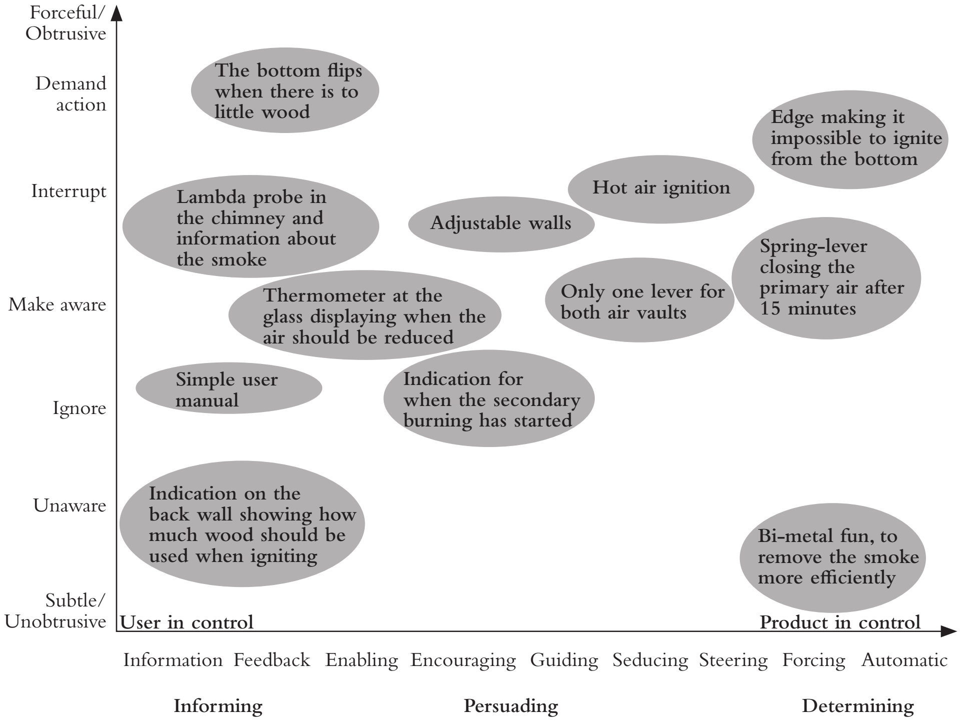


Figure 21.3 Ideas for design interventions plotted into the control–obtrusiveness landscape

have separate leavers for primary and secondary air with no obvious information about the difference between the two. The consequence is that many users do not understand the difference and how they should be adjusted according to each other. As a result, they often do it wrong.

It was concluded that the prototype should have one lever, to make it impossible for the user to close the secondary air but leave the primary air open. When the lever is pulled all the way out, both air valves are completely open; when it is pushed in a bit, the primary air closes but the secondary air is kept open. The further it is pushed beyond this point, the more the secondary air closes, until it is pushed all the way in and the secondary air is completely closed. Also, almost none of the woodstoves on the Norwegian market provides users with information where the air adjustment leavers should be positioned during different stages of the burning process. To help the user understand the different positions of the lever, icons were provided at the position where:

1. both primary and secondary air are completely open (to be used during ignition);
2. primary air is closed but secondary air completely open (to be used for rapid burning); and
3. when primary air is closed and secondary air almost but not completely closed (to be used for slowest possible burning).

To our knowledge, no existing woodstove helps the users understand when the most appropriate time is to make adjustments to the air in this way. The prototype was also equipped with a thermometer on the window at the front of the woodstove, indicating

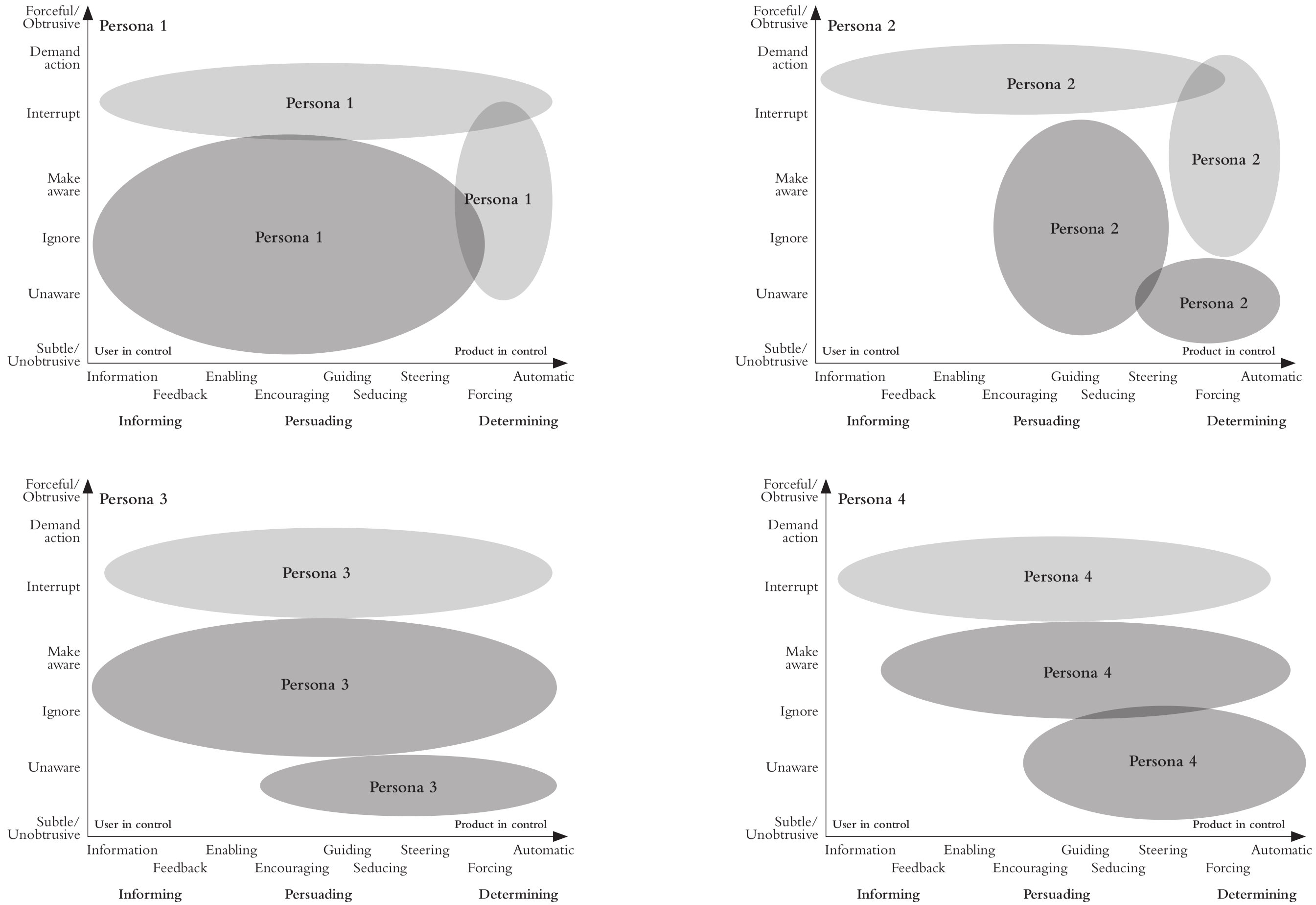


Figure 21.4 Finding out how different personas would react to various control–obtrusiveness combinations

when the air should be adjusted. Lastly, the prototype was accompanied by an easy to read, illustrated user manual.

Details of the testing phase are provided in Daae et al. (2016). In short, 20 participants, all woodstove users on a regular basis, would come to the lab, answer a few questions about their woodstove experience and burning habits, and light a fire in one of the woodstoves – not knowing that there were two, and not knowing the intention of their participation in the test. No explanations were given of how to operate the woodstove, but before lighting the fire the participants were asked to explain what they believed the purpose was of the different parts of the woodstove. During the burning process, the test leader paid attention to what the participant did, but without commenting on it. After the test, the participants of the prototype were asked specifically about whether they had noticed (and used) the steps on the air vault lever, and what they thought of it. All participants were provided with the same choice of lighters, matches and quantity of wood. Measurements were made every minute of the emissions of CO_2, CO, O_2 and NO_x. In addition, the weight of the remaining wood and temperature development in the smoke was recorded, and the total fine particle (PM) emissions were measured.

None of the participants that used the prototype consulted the user manual and the few who noticed the thermometer, thought it was part of the measuring instruments and not something they should pay attention to. However, half of the participants using the prototype noticed the icons and letters before or during the beginning of the burning process, and they all used it actively, both by adjusting the air according to the icons and by naming the letters when talking about what they were doing. Among the participants who did not notice the icons, four out of five were very enthusiastic about them when they were asked about them after the test. They also said they believed they would have interacted differently with the woodstove, if they had noticed them before the test. Only one participant was uncertain about their meaning and thought it would not have affected her if she had noticed them at the beginning of the test.

The way the participants used the woodstoves was analysed to evaluate to what extent their behaviour was in line with the recommendation. Particular attention was given to whether the participants had lit the fire from the top, closed the primary air when it burned properly or adjusted the secondary air and achieved a successful secondary burning.

These criteria, together with other observations and the general evaluation of what the participants had done, provided the basis for rating their behaviour. Based on this evaluation, it was apparent that the five participants who noticed the icons either behaved identical to, or quite in line with, the recommendations. They also closed the primary air, adjusted the secondary air and achieved good secondary burning. Though the sample size was small (the stoves needed to become cold again after every test, allowing for one test per day), the evaluation of all the test results suggested that the prototype resulted in better burning processes than the conventional woodstove. For example, after each test, the ash was removed from the woodstoves, but no other cleaning was done. Before the testing, both woodstoves were almost unused and consequentially had completely clean glass at the sides and on the door. During the testing, the glass surfaces on the conventional woodstove gradually got increasingly opaque, whereas the glass on the prototype stayed clean.

The results indicated that it is worthwhile to explore further how the design of ovens may be improved and do further testing without the variation in the way the participants lit the fire. The primary function of the combined lever was to simplify the air adjustment and avoid the situation where the wrong air valve is closed. Possibly the thermometer could have simplified this even further, but as none of the participants noticed this, the test was unable to evaluate this aspect. However, further simplification of the adjustment of the air valves, and possibly other aspects of the interaction with the woodstove, are undoubtedly possible and potentially valuable.

The fact that only half of the participants who used the prototype noticed the icons, none noticed the thermometer and none consulted the simplified user manual, is in line with the known challenges connected to affecting a habitual behaviour (Klöckner and Matthies, 2004; Verplanken and Wood, 2006), which is likely to be the case for regular woodstove users. In the context of the woodstove, this presents a challenge, as our ethnographic research suggests that a design that would be obtrusive enough to break user habits is unlikely to be accepted by users. Thus, the way the behaviour changing aspects of a new woodstove are presented would benefit from additional research. The lack of attention given to the user manual may also be a consequence of the lack of attention that is generally paid to user manuals, across a broader spectrum of household products. The thermometer was interpreted as one of the many measuring tools attached to the woodstove, and thus may have had more effect if applied in a non-laboratory setting.

The use of Principles of Behaviour Change to evaluate the likelihood of the ideas resulting in the desired behaviour change and being accepted by users, contains a number of potential challenges. First of all, the positioning of the ideas in the landscape is difficult, particularly because the position may depend strongly on how the principle is applied, not only on the type of principle. The results of the analysis only indicate that particular types of principles have the potential to result in the desired behaviour or are likely to be accepted by the user. There may also be several other aspects of the design of a product that also affect the success of the design (Daae and Boks, 2014). Nevertheless, the tool does provide some new insight and can provide additional understanding of how the product affects the user, in addition to the exclusion of directly unsuitable ideas from the ideation process.

Master's-level research projects

The woodstove case study described above was carried out in the context of PhD research at the Department of Product Design at NTNU. Several dozen smaller, though still extensive studies have been carried out as well, mostly as semester-long projects in the context of a Sustainable Design course (Boks and Daae, 2013a, 2013b). Most of these research-based student projects have followed the Principles for Behaviour Change approach, discussed in this chapter. In the subsequent sections, two of these projects are briefly presented, to illustrate how the approach may inspire research processes, factors to investigate and the use of user centred methods to apply in a design for sustainable behaviour process. Though each project was based on following the same Principles of Behaviour Change approach, they all adapted this method to their own needs, sometimes with innovative approaches and ways to visualize the process and findings.

Design of a DfSB solution for ineffective hand washing of household dishes

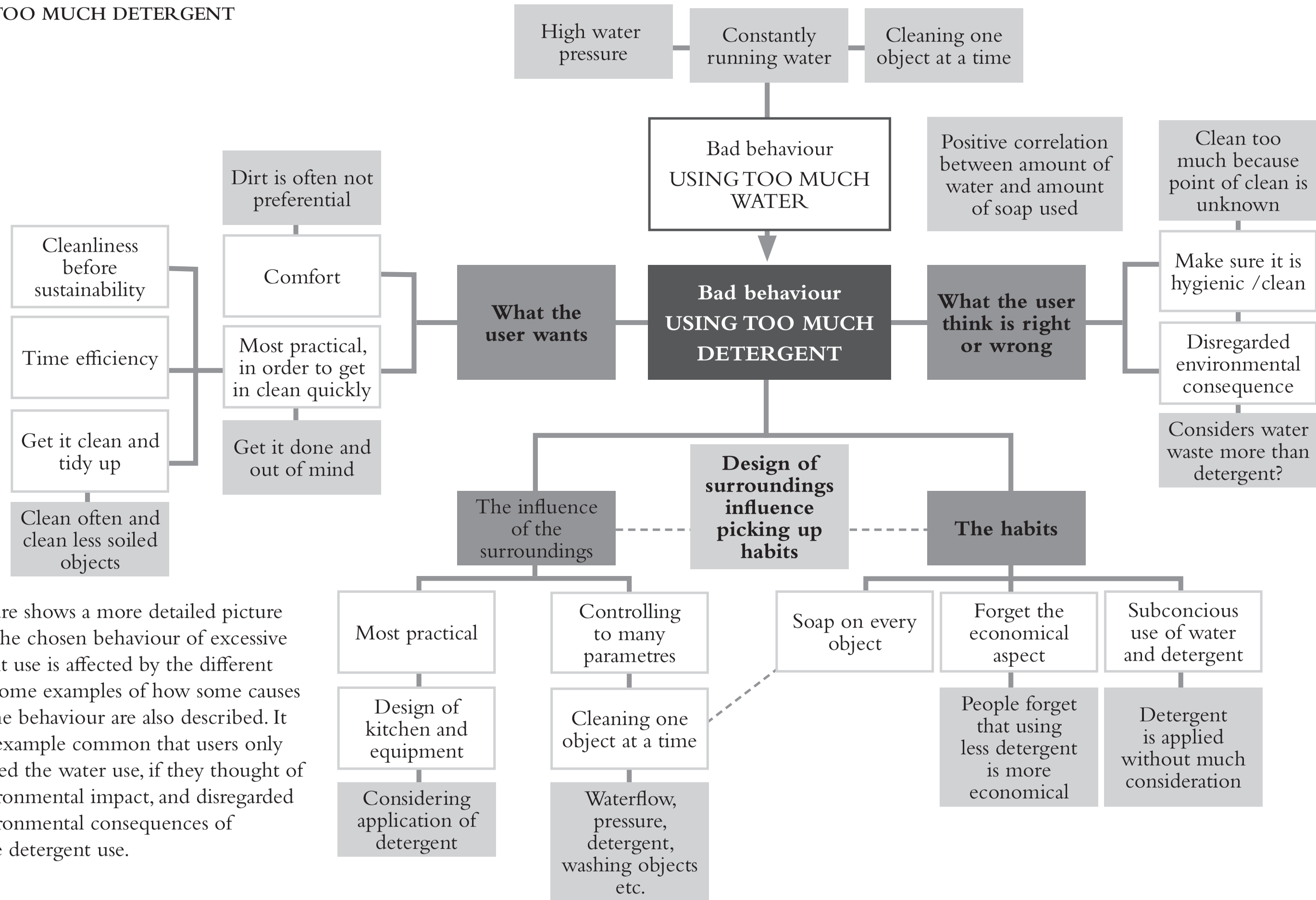
In a project aimed at manual dishwashing behaviour, students used structured observation and structured interviews to develop new insights on behavioural patterns, equipment use, kitchen layout, what users washed up manually, water temperatures and overall cleanliness. They found that bad (unsustainable) behaviours included using too much detergent, running the tap for unnecessary periods of time, using excessively hot water and over-cleaning. It was also found that many users believed they were acting in an eco-friendly way, but in practice were not. Several key factors were found to affect these behaviours, including: habits; outdated beliefs of what was correct dishwashing behaviour; an urge to speed up the process; the amount and type of dishes that needed to be cleaned; lack of vacant space in the dishwasher; equipment available; boredom with the chore itself; and, lack of knowledge about when dishes are sufficiently clean according to general standards and the standards of household members in particular.

A matrix was produced, linking bad (unsustainable) behaviour and cause, which proved very insightful for getting an idea of the solution finding space. It was, for example, common that users only considered water use when thinking in terms of environmental impact, and disregarded the environmental consequences of excessive detergent use.

In this project the Master's-level students adapted Lockton's distinction of users (Lockton et al., 2012), and categorized 'shortcut' (ease is important, adverse to change, lazy, will not investigate, read, notice or put any effort into making a change), 'in between' (distant concern for environmental issues but not at the cost of speed and effectiveness) and 'thoughtful' users (concerned, eager to learn, but still require convenient solutions that give evidence of sustainability before adoption is considered). Using the control-freedom landscape, the group decided to focus on the 'in between user'. It was found that these users are unlikely to want to be controlled by the product, but probably not offended if the product steered the user towards the desired behaviour, as long as it was not too obtrusive. Results from the observations suggested that most users were not reluctant to change their behaviour towards more sustainable patterns as long as it would not inconvenience them, but would jump at a solution to make dishwashing more efficient in terms of time and labour. Therefore the key principles that a solution could incorporate were encouraging, guiding, seducing or possibly mild steering, depending on how much the solutions would need to appeal to those that are most unlikely to change their behaviour. Feedback should be limited to positive reinforcement of good behaviour to keep delivered information mostly unobtrusive. The design dilemmas derived centred around: how to design a product that appears hygienic given that dishwashing is a 'dirty' activity, and how to create something new and exciting with the capability of changing habitual behaviour without it being too obtrusive or determining.

After several iterations with ideation and concept development, this inspired a concept that based on a roller, dispensing just enough detergent to get the job done, in an unobtrusive, hygienic and user friendly way. Combining sloping surfaces, the students created a product that clearly communicates use and direction to potential users. The area around the ball gathers the dirt and keeps the surrounding area clean. The rounded overall shape appears hygienic, with no nooks and crannies where dirt can accumulate. The product is still adjustable in terms of placement so the user retains full control in this regard.

USING TOO MUCH DETERGENT



The figure shows a more detailed picture of how the chosen behaviour of excessive detergent use is affected by the different causes. Some examples of how some causes affects the behaviour are also described. It was for example common that users only considered the water use, if they thought of the environmental impact, and disregarded the environmental consequences of excessive detergent use.

Figure 21.5 Reasons for using too much detergent

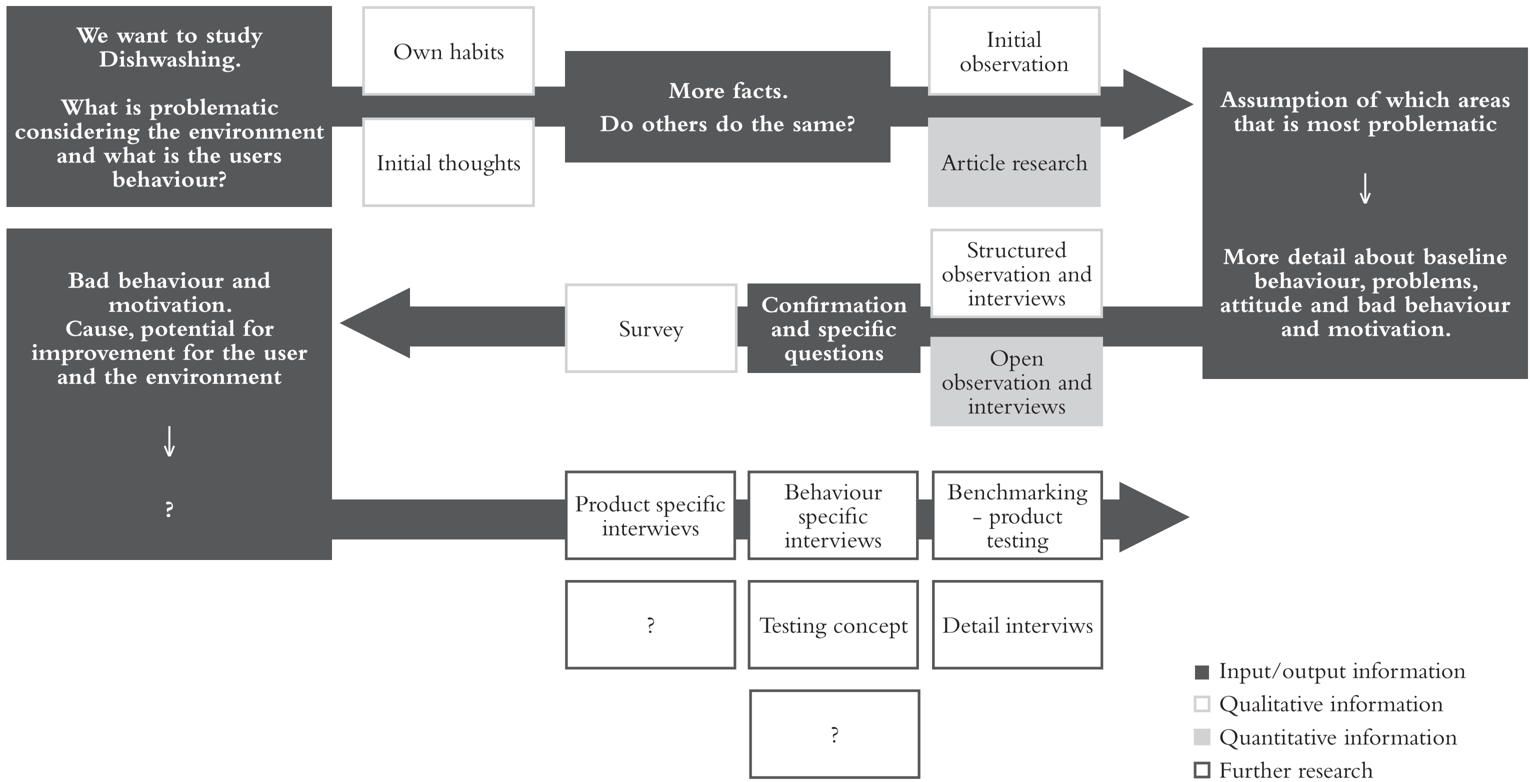


Figure 21.6 Research process

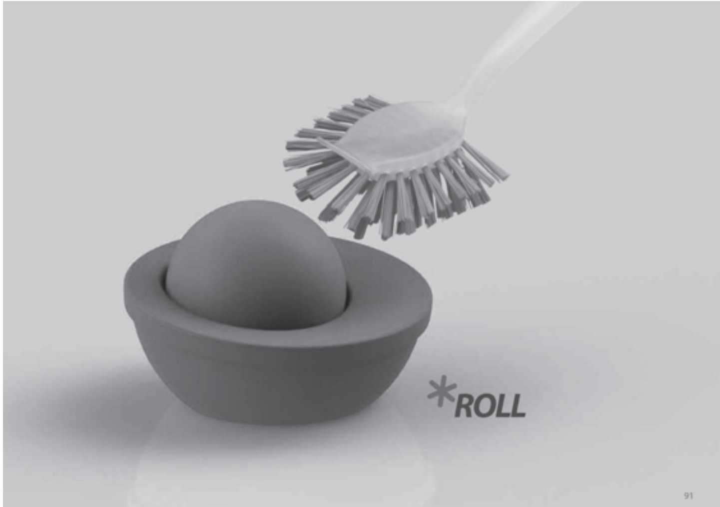


Figure 21.7 The *Roll design solution developed in response to case study data and insight

Design of a DfSB solution for ineffective use of heaters while sleeping

It is widely understood that people spend nearly one-third of their lives sleeping. However, less understood are the heating requirements for sleeping environments, especially in a northern country with long harsh winters such as Norway. In this project, a team of Master's-level students chose to study sleeping habits related to spatial heating during sleeping in student dwellings. This project was undertaken to explore the opportunities for design interventions that could reach those who use more energy for heating than necessary in single-room student accommodations. The students conducted fieldwork to gain understanding of the mindset of various student/consumer groups, seeking to understand what these people do and value when they sleep, and what they would consider to be acceptable for their respective comfort levels. The objective was to develop the groundwork for the design of an effective and appealing product. The students started off by mind mapping all aspects related to sleep, and were particularly active in finding relevant scientific literature on topics such as measurements of temperatures in sleeping rooms, duration of sleep, the effect of humidity on quality of sleep and overheating due to fear of getting too cold. In addition to an online survey for mapping sleep habits the students developed a cultural probe diary that respondents could use to share experiences with hardware use, in the context of their room layouts (such as beds, mattresses, bedlinen) and the heating system (under floor heating, panel heaters, radiators, heat pumps etc.).

It was found that approximately a quarter of the survey participants choose to turn on/up their heating when they felt too cold. Furthermore, 60 per cent of the respondents chose to open the window when their room was too warm. Some of them may also reduce the room heating temperature at the same time, however, this was a relatively small percentage of respondents. Through the survey, it became evident that people generally use more heat than is necessary. This was shown to occur on a daily basis for general use prior to sleep (such as studying, reading, eating, etc.) and users did not adjust their heating in accordance to their sleep preferences. The probes further revealed habits such as turning on the heater fully upon entering the room or just before sleeping, sleeping in little or no clothing and drinking certain beverages that affect body temperature.

It was also found that bed position in relation to the thermostat or the window affected behaviour, as does the type of bed. Another finding was that the context of sleeping makes many people extremely sensitive to what is considered disrupting, stressful or frustrating actions that may be required for establishing a desired behavioural pattern; they value their sleep so much that they are not willing to make any sacrifices in terms of perceived desired heat and comfort levels, such as leaving control over heat levels to an automatic thermostat. Further interesting findings were related to convictions and beliefs: people keep the heat on all night because they are scared of getting cold, they leave (often simultaneously) the windows or door open because they think airing out brings health benefits and they believe that the health effects of sleep outweigh any environmental consequence of unsustainable behaviour. As a result, bedrooms often end up being too warm or hot during the night.

Related to this, people fail to take steps to regulate bed and body temperatures prior to and during sleep. The easy solution is to warm up the entire room. Focusing on the bed temperature instead of room temperature could reduce overall heat usage. By focusing on these two behaviours, the ambition was to reduce the impact of the above observations. Based on these insights, the students identified three main behavioural patterns, and developed three *personas* accordingly.

- *Persona 1*: is aware of his/her energy usage, and keeps track of it in some way or another. Is generally environmentally responsible (such as using extra blankets when cold, turning off electronic devices before sleep).
- *Persona 2*: prefers to be warm and get fresh air at the same time, leaving the window open with the heat turned on. Routinely charges smart phone and laptop at night. Is open to changes if they do not compromise convenience too much.
- *Persona 3*: may or may not behave routinely environmentally friendly when engaged in other activities, but will not compromise or bulge when it comes to sleeping habits. Sticks to sleeping routines and will not give away control to for example automatic thermostats.

A number of design dilemmas were consequently identified. First of all, the sleep temperature preference is highly variable. While one individual prefers warm sleeping temperatures, there are others who prefer cooler sleeping environments. In other words, what is comfortable for one person may be unbearable for another. Moreover, many student dwellings are multi-functional and accommodate not just sleeping, but also eating, relaxing and studying. These different activities also typically require variable temperature settings. This makes designing an intervention challenging when the aim is to cater for a significant user group. In addition to individual characteristics and body behaviour, people also possess varying aptitudes when it comes to electronic products and devices. Early on in the research, the students considered technology-based solutions, but this also created a dilemma: if a design solution was to be technology-based, different technology competencies of users must be taken into account. In the end, the product must exhibit intuitive functionality to all potential users, so that even the laziest of users were not put off. Another consideration was that the target group (students) is highly mobile. For example, many students change dwellings quite frequently for various reasons, posing challenges on a design solution particularly if the device is to have intelligent memory (remembering user habits).

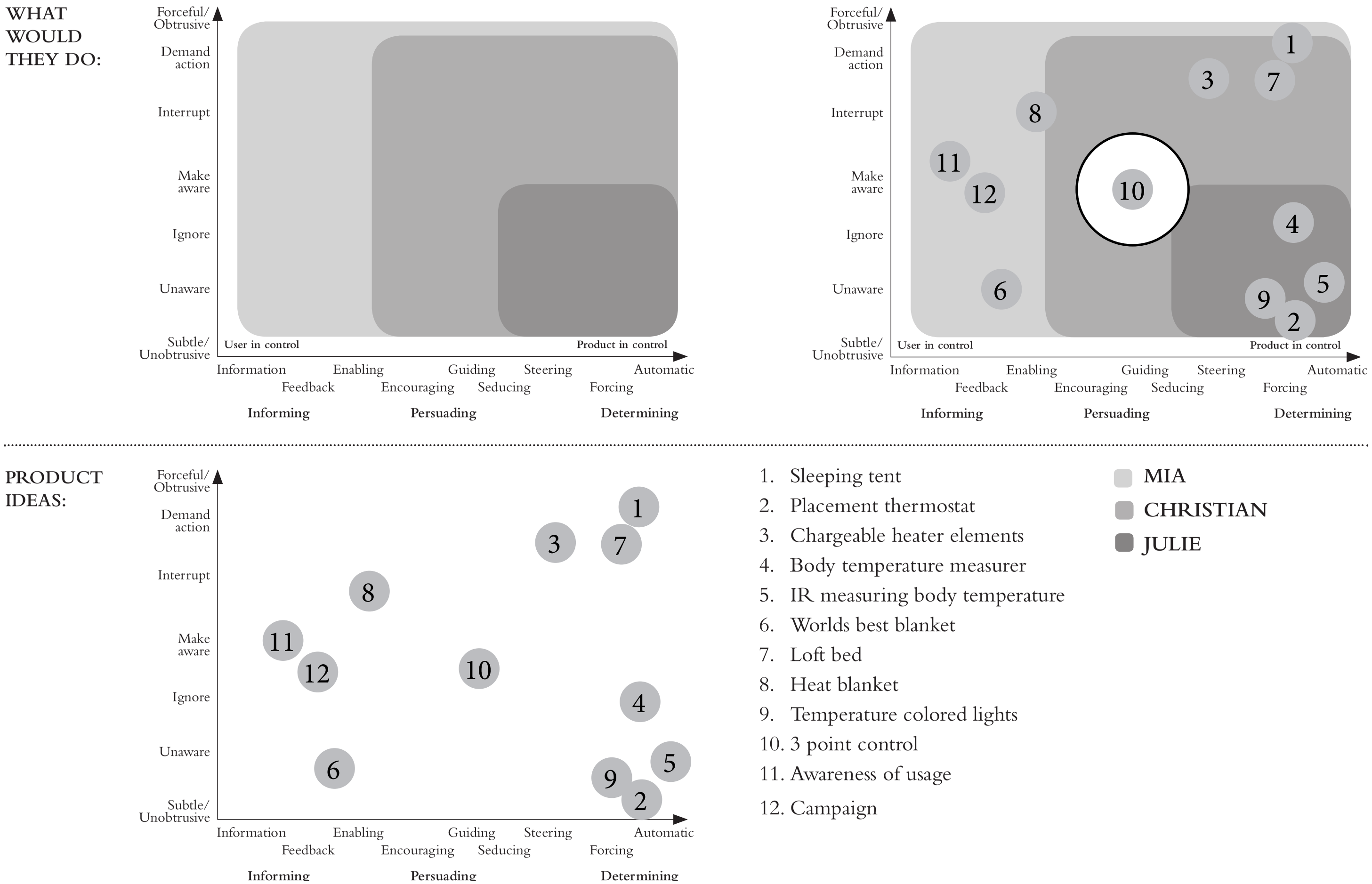


Figure 21.8 Mapping ‘forceful/subtle’ and ‘user in control/product in control’ scenarios

Through a design ideation phase, the students selected twelve ideas that could contribute to solving the core design challenges that were identified. These included sensors measuring body temperature controlling the heater, creating lighting that provide a correct or incorrect sense of actual room temperature, creating a microclimate around the bed and various other architectural solutions. The students realized that the key to the solution was to increase the ease with which bedroom temperatures can be appropriately adjusted, and that awareness and motivation are the key aspects to triggering environmental gains with respect to sleep – at least for persona one and two, who are willing to delegate some level of control to technology. Using the Principles of Behaviour Change landscape to arrange the solutions according to what users may prefer or be sensitive to, it was decided to focus on a three-point control device consisting of a heater adapter, control panel and a cell-phone application; essentially connecting the heater to the alarm function on the smart phone, allowing the heater to understand when the user goes to bed and plans to wake up, enabling it to adjust heat to a desired, sustainable and healthy level. This was also motivated by the fact that existing solutions to adjust the heat, traditional programmable panel heaters, are designed for people that actively should make an effort to reduce their energy consumption. They are static, in the sense that they (after programming) lower the temperature at the exact same time each day, regardless of when you go to sleep, and at what time you get up. This functionality automatically excludes the majority of users. The solution was partially inspired by one of the cards of the Design with Intent toolkit (Lockton, 2013), the one that suggests to make the desired behaviour the default behaviour.

Conclusions

This chapter has provided insights into how a user-centred design process may lead to suggestions for reducing environmental impacts during use phase interaction between users and products. The user-centred design process described in this chapter is informed by behavioural psychology, and makes use of the toolkit of methods that designers have available. This toolkit exists of widely used methods such interviews, observation and ethnography, as well as methods developed specifically for changing behaviour, such as Principles for Behaviour Change and Design with Intent.

In the main case presented, which focused on the redesign of a woodstove, the process covered everything from problem identification, anthropological research and several iterations of ideation and redesigning, to blind testing by comparing emissions from a conventional and a prototype woodstove. Two smaller cases were also discussed to show variations on this approach, developed as far as the design conceptualization phase.

This, however, by no means implies that research has provided a final answer as to how approach these and similar research questions. Design for Sustainable Behaviour is young field, which has still much to gain from more extensive cross fertilization with fields such as practice theory, persuasive technology and behavioural psychology. Therefore, a key challenge for future research will be to test whether effects of (re)design interventions are truly sustainable in the long term, as we (sometimes) assume (too easily) they will be. Neither does the current state of the art provide a meaningful roadmap to implement such approaches within industry and the public sector. In the future, DfSB must expand its focus, to include the role of other actors relevant to design and use and the development of interventions involving multiple actors (Pettersen, 2013). Another approach could be to take DfSB approaches and apply them on firms, or on other societal stakeholders. Looking upon them as actors, in the same vein as we look at individual consumers as actors, we can think of ways of informing or forcing them, or most interestingly, seducing them to integrate sustainability into their activities.

Acknowledgements

This chapter is partly based on recent publications in the *International Journal of Sustainable Engineering* (Daae and Boks, 2015a) and the *Journal of Design Research* (Daae et al., 2016), as well as a conference paper by Boks et al. (2015). The authors also acknowledge the students that have indirectly contributed to this article through their assignments for the sustainable design course at NTNU's Department of Product Design.

References

Boks, C., Daae, J. (2013a) 'Towards an Increased User Focus in Life Cycle Engineering: Re-engineering Manufacturing for Sustainability'. *Proceedings of the 20th CIRP International Conference on Life Cycle Engineering*, Singapore, 17–19 April.

Boks, C., Daae, J. (2013b) 'From Teaching Sustainable Product Design to Teaching Sustainable Behaviour Design'. *Proceedings of Cumulus 2013, The 2nd International Conference for Design Education Researchers*, Oslo, 14–17 May.

Boks, C., McAloone, T. C. (2009) 'Transitions in Sustainable Product Design Research'. *International Journal of Product Development*, vol 9, no 4, pp429–449.

Boks, C., Lilley, D., Pettersen, I. (2015) 'The Future of Design for Sustainable Behaviour, Revisited'. *Proceedings of Ecodesign2015*, December, Tokyo, Japan

Daae, J., Boks, C. (2014) 'Dimensions of Behaviour Change'. *Journal of Design Research*, vol 12, no 3, pp145–172.

Daae, J., Boks, C. (2015a) 'Opportunities and Challenges for Addressing Variations in the Use Phase with LCA and Design for Sustainable Behaviour', *International Journal of Sustainable Engineering*, vol 8, no .3, pp148–162.

Daae, J., Boks, C. (2015b) 'A Classification of User Research Methods for Design for Sustainable Behaviour'. *Journal of Cleaner Production*, vol 106, pp680–689.

Daae, J., Goile, F., Seljeskog, M., Boks, C. (2016) 'Burning for Sustainable Behaviour', *Journal of Design Research*, vol 14, no 1, pp42–65.

Haakonsen, G., Kvingedal, E. (2001) *Utslipp til luft fra vedfyring i Norge Utslippsfaktorer, ildstedsbestand og fyringsvaner*. Statistics Norway, Norway.

Karlsvik, E., Oravainen, H., (2009) *Guidebook – Effective and Environmentally Friendly Firing of Firewood*. Intelligent Energy, Europe.

Klöckner, C., Matthies, E., (2004) 'How Habits Interfere with Norm-Directed Behaviour: A Normative Decision-Making Model for Travel Mode Choice'. *Journal of Environmental Psychology* vol 24, no 3, pp319–327.

Lilley, D., Wilson, G. T. (2013) 'Integrating Ethics into Design for Sustainable Behaviour'. *Journal of Design Research*, vol 11, no 3, pp278–299.

Lockton, D. (2013) 'Design with Intent: A Design Pattern Toolkit for Environmental and Social Behaviour Change'. Doctoral dissertation, Brunel University School of Engineering and Design.

Lockton, D., Harrison, D., Stanton, N. A. (2012) 'Models of the User: Designers' Perspectives on Influencing Sustainable Behaviour'. *Journal of Design Research* vol 14, no. 10(1–2), pp7–27.

Miaskiewicz, T., Kozar, K. A. (2011) 'Personas and User-Centered Design: How Can Personas Benefit Product Design Processes?' *Design Studies* vol 32, pp417–430.

Ozil, F., Tschamber, V., Haas, F., Trouvé, G. (2011) 'The "Zero-CO" Domestic Fireplace: A Catalytic Solution to Reduce Pollutants'. *Management of Environmental Quality: An International Journal* vol 22, pp429–439.

Pettersen, I. N. (2013) 'Changing Practices: The Role of Design in Supporting the Sustainability of Everyday Life'. Doctoral dissertation, Norwegian University of Science and Technology.

Verplanken, B., Wood, W. (2006) 'Interventions to Break and Create Consumer Habits'. *Journal of Public Policy and Marketing* vol 25, pp90–103.

Wilson, G. T. (2013) 'Design for Sustainable Behaviour: Feedback Interventions to Reduce Domestic Energy Consumption' Doctoral dissertation, Loughborough University.

Zachrisson, J., Boks, C. (2011) 'Obtrusiveness and Design for Sustainable Behaviour', *Proceedings of Consumer 2011*, 18–20 July, Bonn.

Zachrisson, J., Boks, C. (2012) 'Exploring Behavioural Psychology to Support Design for Sustainable Behaviour Research'. *Journal of Design Research* vol 14, no 10(1–2), pp50–66.

Zachrisson, J., Storrø, G., Boks, C. (2011) 'Using a Guide to Select Design Strategies for Behaviour Change: Theory vs. Practice'. *Proceedings of EcoDesign 2011, Design for Innovative Value Towards a Sustainable Society*, Kyoto, Japan, 30 November–2 December, pp362–367.