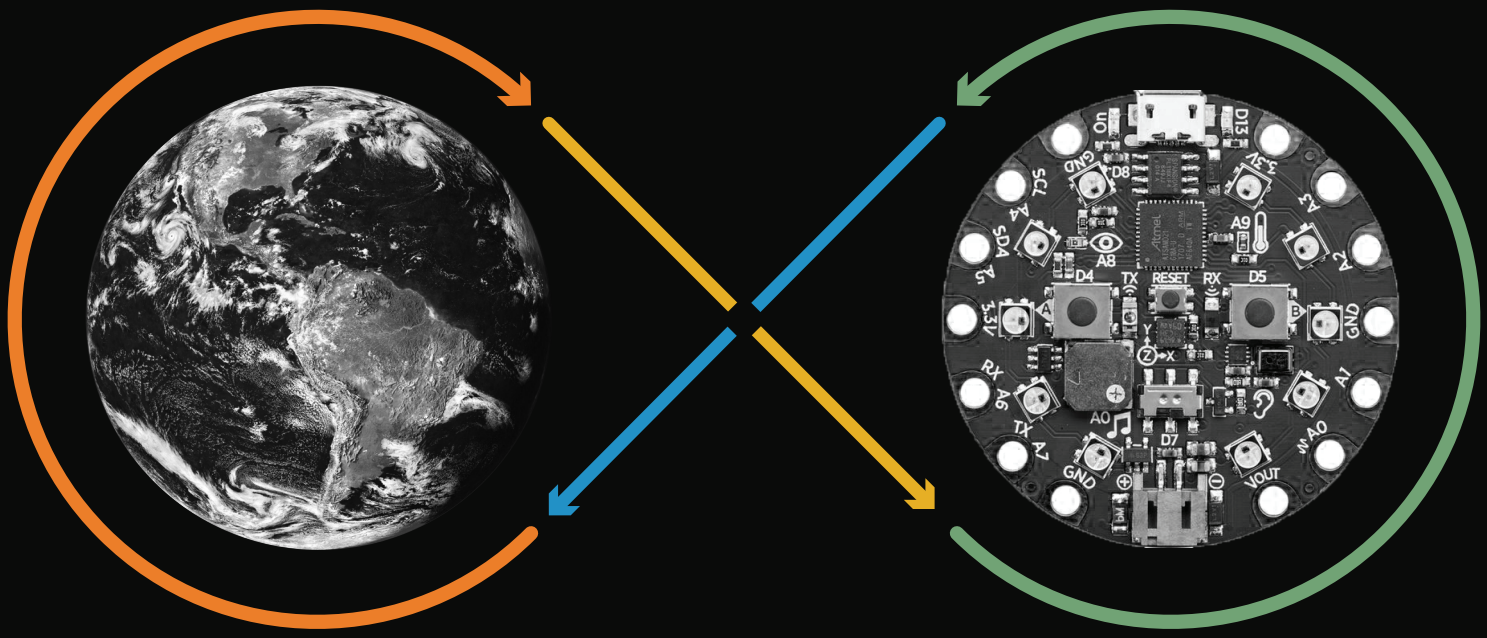
ECO-DESIGN IN LEAN STARTUPS



TOOLS FOR THE DISCOVERY OF BENEFITS FOR STARTUPS IN PRACTICING ECO-DESIGN

MAX KERSTEN

ECO-DESIGN IN LEAN STARTUPS

TOOLS FOR THE DISCOVERY OF BENEFITS FOR STARTUPS IN PRACTICING ECO-DESIGN

by

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Eco-Design in Lean Startups

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Executive Summary

The majority of a product's ecological impact can be attributed to the design phase (Ramani, et al., 2010). Yet, adoption of eco-design methods into business practice has been relatively slow (Baumann, et al., 2002). For the environment it could be a huge positive step, if this adoption is improved. However, companies see introducing eco-design as a costly endeavour, since the they don't clearly understand the benefits they can gain from it (Schick, et al., 2002; Nidumolu, et al., 2009).
This report explores how the Lean Startup method (Ries, 2011) could be of use regarding the posed issue. This method is aimed at efficient resource use and fast iterative learning cycles (Maurya, 2010), which means it has the potential to let businesses quickly discover how eco-design could benefit them without high cost. The opportunity is further explored by focusing on startups. This company form has a high need for using the Lean Startup method, because detailing a new business model is resource intensive (Sommer, et al., 2009; Ries, 2011), so efficiency is preferable. Next tot that, startups are found to have the highest likeliness of a successful eco-design introduction, compared to other company forms. Anderson and Leal, 1997). The research question posed in the project is:
'how can eco-design methods be brought into startup practice by introduction via the Lean Startup method?

Based on the insights of a literature study and interviews with startup founders, an eco-design method was chosen. This tool name quality functional deployment for the environment. By means of iterative testing with founders the tool has been improved. The outcome is the Improvement Identifier Canvas.

Improvement Identifier exist out of five elements: three working sheet, change diagram, and an instruction slide deck. In short the tool works as follows. A startup founder identifies certain changes that could be beneficial for his startup. On a second canvas he details the elements of his current business model. The possible links between the current business and potential changes are assessed, and the founder is now able to tell which changes could be the most beneficial to pursue. At this moment, the Change Diagram is of great importance, because this diagram has an overview of how changes are linked to benefits and eco-design methods to realise the changes.

The main benefit of this method is that it is build on the principle of opportunity identification (Herrmann, et al., 2008; Volkmann, et al., 2009; Lourenço, et al, 2012). An often heard complaint from startups about eco-design is that it isn't applicable to their specific situation (Schick, et al., 2002). Now with the Improvement Identifier the power is put in their own hands. They explore different changes to make or different benefits to gain. The tool also contains many other benefits for business. Read the report to get to know those as well.

Within the duration of this project it was not possible to fully answer the research question. By using the improvement identifier canvas, startup founders are introduced to eco-design methods and how they could benefit their practices. However, following the research question, the startup founders also should start using the eco-design methods, and this use should be related to the Lean Startup method.

Half of the test users of a case study were determined to pursue the practice of an eco-design method after they used the Improvement Identifier. However, since it was a case, we won't know if they actually would have followed through. Research even shows that eco-open founders often don't match their actions to the initial attitude (Tilly, 1999; Schick, et al., 2002).

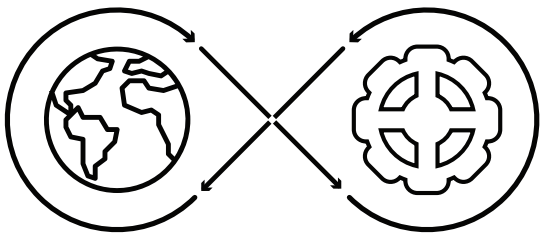
To conclude, the product of this project is a well-received tool, that can offer a plethora of benefits to startups. But the future dynamics of the situation are still a mystery, which means it cannot be determined yet if eco-design methods will make it into startup practices. The question at hand is, Will the startup founder put his resources (read: money) where his mouth is?

THE CONTENT

Preface

Startups have fascinated me for years. They are companies that seem to come out of nowhere with the most amazing innovations. What stuns me even more are the entrepreneurs behind these young ventures. Such startup founders often don't have the background education needed to make a company a success, but still they manage to prevail. This is interesting from my perspective as a student of strategic product design, because at this study you do learn a great deal about how to run innovative businesses. I would even go so far as saying I believe that people from this master are the perfect candidates to start new ventures. I was intrigued about how the knowledge of design could perhaps enhance the world of startup companies.

Ecological design became the focus of this project, since I knew from experience that this methodology doesn't only benefit the environment. It also can benefit the company applying it in a variety of ways. Besides, the ecological decay of our planet has been a hot news item lately, which makes the relevance of this project topical. Nonetheless, the task of matching eco-design and startups didn't have a straight forward solution. It has been quite a search to find a useful way of connecting the two. I found a connection via the Lean Startup method, which kicked off this project.



1 THE PROJECT

This chapter establishes the state of design for environmental sustainability and frames the position of this project in that context; an introduction of eco-design into practice via the Lean Startup method. The realisation is approached via a research with startups. The steps of which are further detailed in this chapter.

1.1 Project

INTRODUCTION TO THE PROJECT

”Human beings don’t have a pollution problem; they have a design problem.” (Braungart & McDonough, 2013). This statement reframes the cause of global environmental decline by shifting the focus from the user to the designers. It aligns with the ‘Shadow of Design’ (figure 1.1-1), the finding that the main influence (70%) on the costs of a company is committed in product design (Munro, 1989; Ullman, 1992), and it’s suggested that the majority of a product’s ecological impact is committed in this stage as well (Ramani, et al., 2010). The field of design isn’t unaware of the ecological footprint it creates. The academic research on ecological design (read ‘Define Eco-design’ for the used definition) has been growing since the early nineties and really started taking off in the past decade (Ceschin & Gaziulusoy, 2016). However, the adoption of eco-design into business practice has been relatively slow (Baumann, et al., 2002). The number of people educated in the area of eco-design is limited, accordingly companies need to start acquiring these competencies internally for the adoption to accelerate. Which begs the question, what is keeping companies from acquiring eco-design competencies? For many, the benefits of putting eco-design into practice are unclear (Schick, et al., 2002; Nidumolu, et al., 2009), so allocating resources to acquiring the necessary skills doesn’t seem like a solid investment.

“Human beings don’t have a pollution problem; they have a design problem.”

DEFINE ECO-DESIGN

Terminology around sustainability isn’t consistently used (Boons, et al., 2012). News stories often use terms like ‘environmental sustainability’ to address greenhouse gases and energy use. In some occasions sustainability refers to the trifecta of people, planet and profit; triple bottom line. In this project the focus is at the whole environmental impact a product, service or business makes along its life cycle. This means it goes broader than emission during use. The life cycle of a product starts when materials are delved and ends with the disposal of the product. The term ‘eco-design’ will be used to denote this focus in the project.

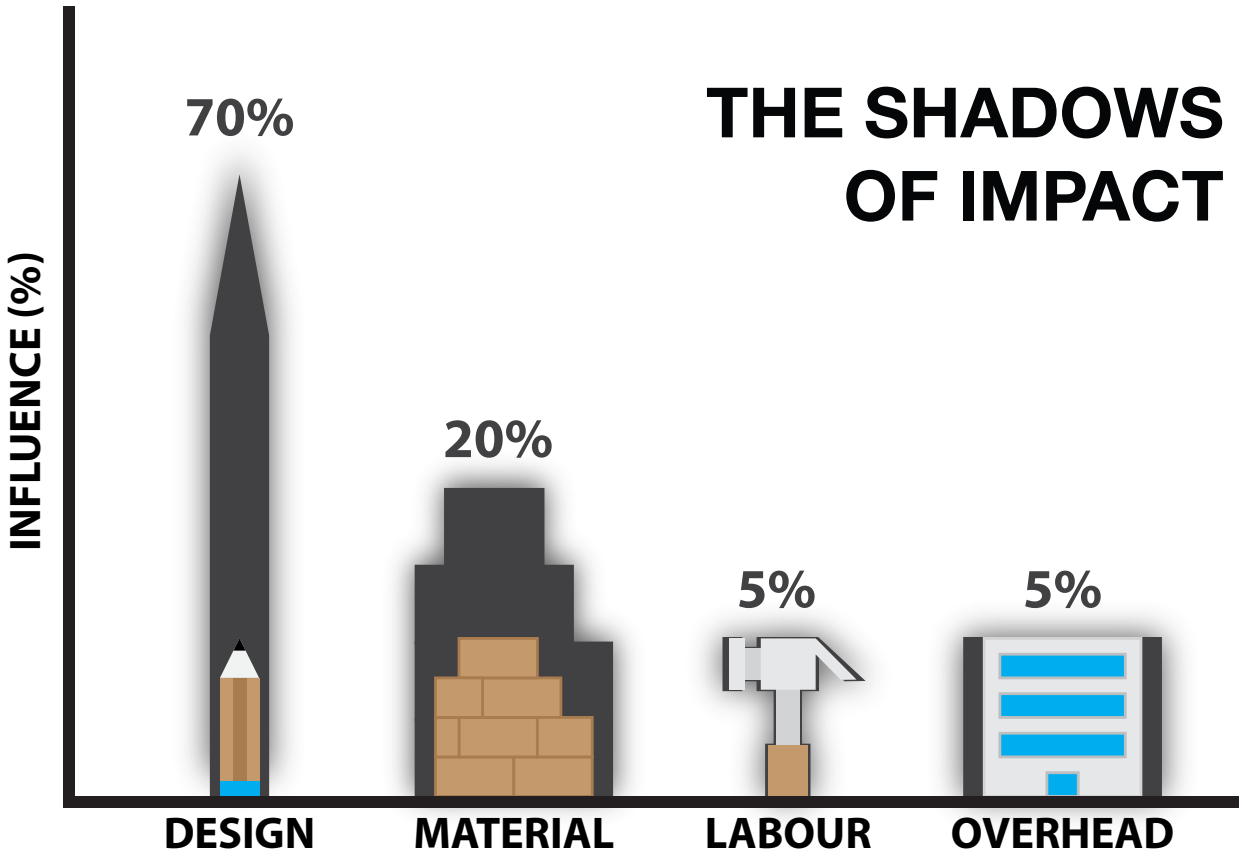


Figure 1.1-1: visualisation of what influences a company's cost (Munro, 1989; Ullman, 1992) and probably ecological impact as well (Ramani, et al., 2010).

The Lean Startup (Ries, 2011), a method of which adoption by companies is rapidly growing (Innovation Leader, 2016), relates to the lack of allocation of resource to acquiring eco-design competencies in two ways. This could make the Lean Startup a worthwhile opportunity to explore. The method supports companies during innovation processes by means of efficient use of resources, which lowers the barrier for investigating new directions. Secondly, the Lean Startup is based on lean thinking, which has a similar objective to eco-design: reducing waste (Womack, 1990). Thus the Lean Startup method could allow a company to discover the potential benefits of bringing eco-design into practice without requiring a large commitment of resources. Nonetheless, there is some friction between this method and ecological design as well. Designing for environmental sustainability is seen as a long-term plan (Nidumolu et al., 2009), in contrast Lean Startup favours a fast iterative development process (Maurya, 2010). If this friction can be overcome, it could introduce a path to accelerating eco-design in business practice, which raises the question: how can eco-design methods be altered to conform to the Lean Startup method for introduction into practice?

1.2 Project

APPROACH TO THE PROJECT

The questions ‘how can eco-design methods be altered to conform to the Lean Startup method for introduction into practice?’ is answered from the perspectives of young ventures in this project. In these startup companies the use of the Lean Startup method is common practice. Lean Startup helps the ventures make effective use of the limited resources they have available in their start-up phase. Startups also show the most promise for the introduction of eco-design compared to other organisational structures (Anderson and Leal, 1997). This makes startup companies seem as a good angle of approach. With this approach the main research question of the project becomes: ‘how can eco-design methods be brought into startup practice by introduction via the Lean Startup method?’.

The Lean Startup method (Ries, 2011) is also applied on this project to answer the research question. This method is used because there is not much research on the connection between the fields of eco-design and startups existing yet (Choi and Gray, 2008), which can’t be fully explored in the limited time duration of this project. The use of the Lean Startup method results in an iterative approach fuelled by direct input of real startup founders. This leads to a project approach as follows.

RESEARCH QUESTION

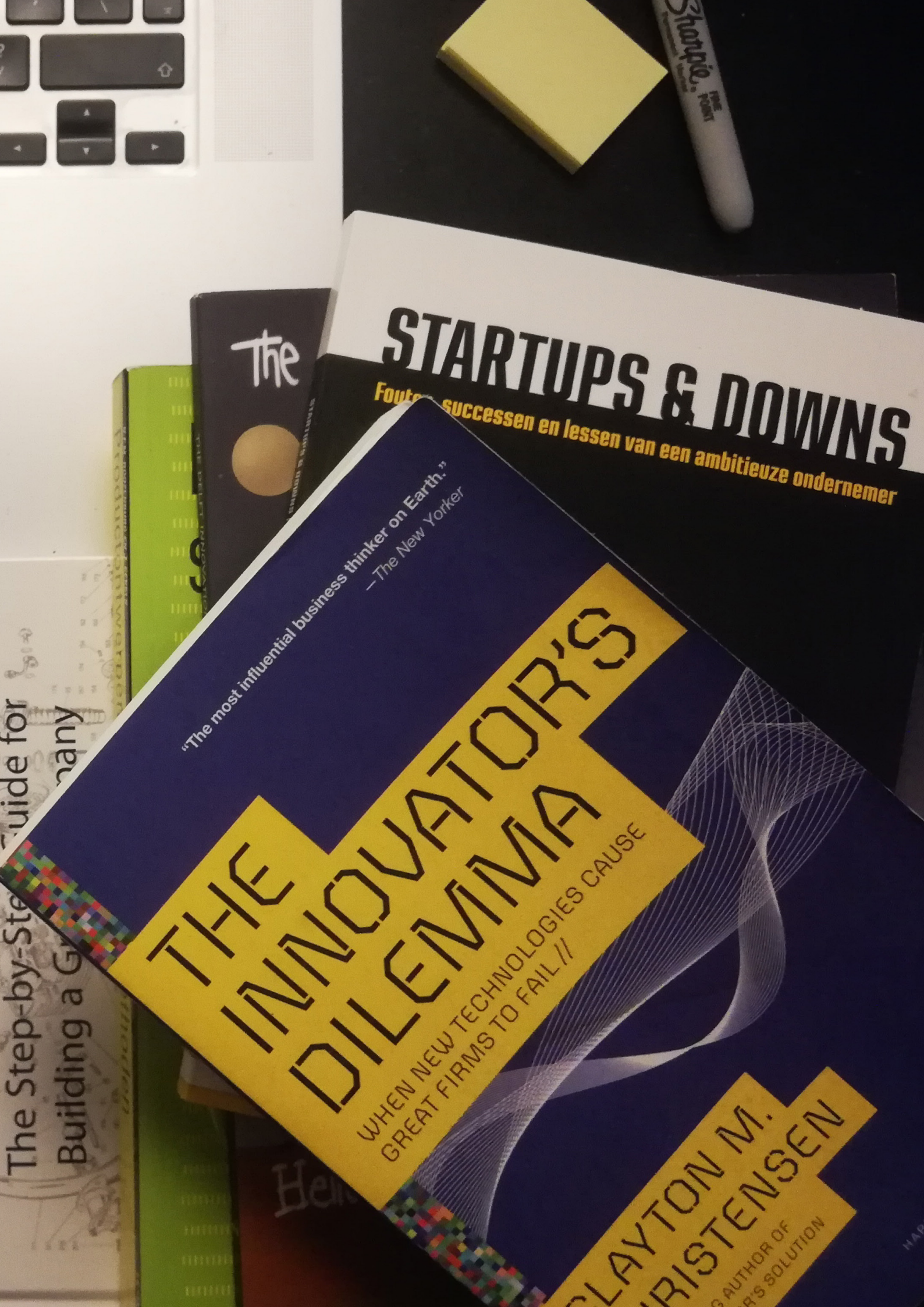
How can eco-design methods be brought into startup practice by introduction via the Lean Startup method?

The first step towards answering the research question ‘how can eco-design methods be brought into startup practice by introduction via the Lean Startup method?’ is to see what the academic fields related to the question have to add. Four areas for literature exploration have been identified from the research question: startup practices (Chapter 2.1.), the Lean Startup method (Chapter 2.2.), eco-design (Chapter 2.3.) and means of introduction (Chapter 2.4.).

With a background understanding of the fields related to the research question, conversations with startup founders can be engaged. Chapter 3 details how an empirical user research is conducted with founders to get insight on what benefits they would like to gain, criteria for an eco-design method to be introduced, and the frame of processes this method would have to fit in.
The input of the founders together with the literature study provides the information to choose an eco-design method. In chapter 4 it is detailed how this method is chosen and redesigned to be fitting with lean startups.

By means of iterative testing (Chapter 5) the eco-design method is improved with the input of startup founders. Chapter 6 details the final design of the eco-design method and its introduction.
To assess the performance of the finalised method, a case study is held (Chapter 7). The case study is a more controlled form of testing, which makes the output better comparable.

This report is concluding with chapter 8, which evaluates if the research question is answered. Furthermore, this chapter details what the implications of the outcomes are and gives recommendations on future steps. To end the report, discussions on the limitations of the research are provided in chapter 9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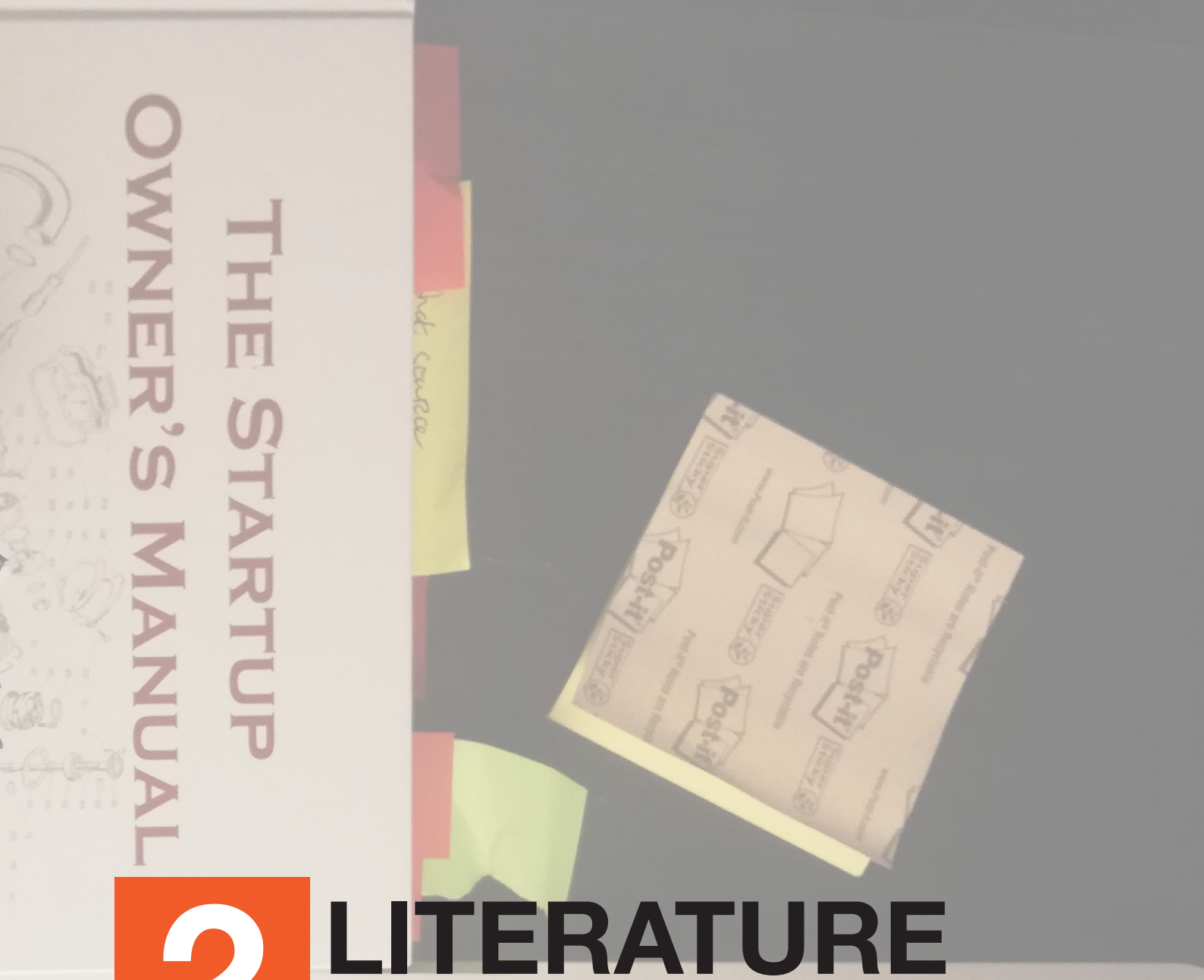


2 LITERATURE STUDY

The first step towards answering the research question 'how can eco-design methods be brought into startup practice by introduction via the Lean Startup method?' is to see what the academic fields related to the question have to add. Four areas for literature exploration have been identified from the research question: startup practices, the Lean Startup method, eco-design and means of introduction. The sub-chapter 'startup practices' addresses the fundamentals of this company form and their opinion about eco-design. The following part is about the principles of the Lean Startup method. In the sub-chapter about eco-design the frictions between its approach and the Lean Startup are discussed and ways for interesting lean startups in eco-design are identified. The last sub-chapter talks about how introducing a new concept to a business, like eco-design for startups, can create its own challenges that need to be resolved.

2.1 Literature

STARTUP PRACTICES

Startups are a natural fit with the Lean Startup method, since they have to deal with limited resources. In this chapter it is discussed what puts startup companies in this situation. Furthermore, researchers have posed that startups are the most promising company form for an eco-design introduction, thus this chapter addresses the openness of startups towards exploring the possibilities of eco-design.

2.1.1. Cause: Uncertainty

The idea of the startups has been turned into stories about success. This is the result of some companies growing to a net worth of millions or even billions in just a few years. These are companies like Uber, AirBnB and Slack. But only few young ventures are so lucky. The failure rate of startups is extremely high (Shane, 2012). 50% of startups is expected to fail within the first 5 years (Shane, 2008). Depending on the source such numbers can greatly vary due to the many factors at play for measuring the failure rate (read the side note 'the real failure numbers' for the details). Nonetheless, one factor can be pointed to as the greatest cause for increasing the average; high uncertainty.

Ries (2011) explains the high uncertainty startups by defining which businesses don't fit in this group: predictable businesses. Clones of existing businesses have understood risks and uncertainties making success easy to predict and mostly depended on execution and planning (Ries, 2011). As an example, a bakery has been started by many people before, and thus most pitfalls are known because of these previous attempts. Your success of starting a new bakery can be reasonably predicted, thus a predictable business.

Traditionally risk management would be applied to a new project to guarantee success (Smith and Merritt, 2002). However, in the case of high uncertainty startup not all risks are identifiable yet, which gives many potential areas of risk that need to be managed. Only startups aren't able to cover a wide range of risks, because that would require many man-hours, which is not at the disposal of startups (Sommer, et al., 2009). In managing risk, high uncertainty startups are thus restricted by the available resources.

2.1.2. Resource Restrictions

Startups require resources to deal with uncertainty (Sommer, et al., 2009), but why is allocating resources to reduce uncertainty a difficult task?

Grand Experiment

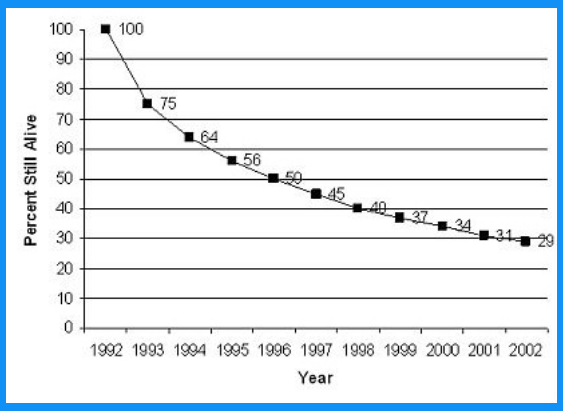
Ries (2011) says we should visualise a startup "as a grand experiment". In the past, answering a single question, "can this product be built?", was often sufficient for the success of a business. Nowadays more questions need to be asked, so a grand experiment. The most important question to answer is "can a sustainable business be build around this product?". Sustainable here means that a business can balance its resources to create long-term economic growth. A business model can be divided in three main elements (Bocken, et al., 2013):

- Value proposition
- Value creation & delivery
- Value capture

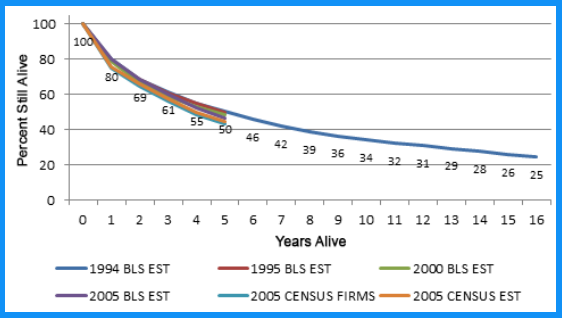
The value proposition is about the certain benefits a business wants to provide to a customer segment by means of a product. This entails mostly research and design to find a good fit between product and customer. The element 'value creation & delivery' includes how the product is realised (e.g. technology development, manufacturing, supplier partnerships) and how the customer gains access to it (e.g. sales channels, delivery partnerships). Value capture is aimed at the business itself. It is the value the company gets out of

THE REAL FAILURE NUMBERS

Numbers regarding startup failure vary greatly per source. Multiple factors are at play here, most of the difference is due to location, sector, and timing of the measurement. However, Shane (2008) showed that rate of failure over the lifetime of startups is consistent despite of such factors (figure 2.1-1). Some doubt on this research was caused due to the numbers being from around the dot com bubble, but Shane repeated the research with new data reaching until 2010 (Shane, 2012), and found similar rates of failure (figure 2.1-2). After a business reaches twelve-years of age the chance of failure levels to a steady 5 percent (Shane, 2012), so this can be considered the marker of when a company stops being a startup.



Above Figure 2.1-1: Failure rate of startups (Shane, 2008).
Below Figure 2.1-2: Failure rate of startups measured at multiple occassions (Shane, 2012)



creating and delivering a product. This encompasses revenue streams, but also the costs that have to be subtracted.

As illustrated, secondary to the 3 elements there are many facets to a business model. These facets interact with one another, which makes it difficult to allocate resources to an area without affecting other.

Burning Resources

Another way of looking at the resource restrictions is by how the fundamental resources interact with each other. Naturally a startup company has man-power, at least in the founders of the business. Man-power intrinsically brings cost and time with it. Not necessarily in the form of salary, but costs are made and time is spend because the startup founders could have spend their efforts on other opportunities of creating value as well. Since the startup is “a grand experiment” (Ries, 2011), the man-power is spend on knowledge acquisition to be able to reduce the uncertainties of the business. It makes knowledge and man-power, expressed in cost and time the fundamental resources. Because the resources are expressed in cost and time, there is a pressure behind the process of resource allocation, since cost will increase over time. This gives a time limit at which the cost have become too high to maintain the startup.

To return to the question, why is allocating resources to reduce uncertainty a difficult task?
It is due to the interrelations of the business model facets. Because of the interrelations, tackling one uncertainty will also affect others. Uncertainties can’t be resolved in a vacuum, one by one. A holistic approach has to be taken to business development, which will be man-power intensive. An intensive use of this fundamental resource will directly decrease time limit of the company due to the increased cost.
Although, since the resources are interlinked, changing one resource aspect positively could also extend the life-time of a startup. With this in mind a new question arises, what are sources for decreasing the restrictions set by resources on the business development?

Decrease Restrictions

A startup needs to find ways to deal with the restrictions of resources on the business development processes. If a young venture does not learn this, the many uncertainties most likely will lead to the failure of the business. Based around the notion of the startup as an experiment about a business model three ways of decreasing restrictions of resources can be identified: capital inflow, 3rd party knowledge, increased efficiency.

Naturally, having an incoming flow of capital will give an extension of time on the existence of a business. There are 3 sources for capital: sales, funds and investments. All three have pros and cons. Early on, sales is probably

the hardest to achieve, since it would require the basics of 3 out of 3 of main business model elements (Bocken, et al., 2013). For funds and investments establishing a value proposition is often the only requirement, while for the other two aspects a conceptual plan is sufficient. With investments the idea behind the 'value capture' requires extra attention since investors expect a return on investment, which is not the intention of a fund.

Instead of capital to spend, a second possibility is to acquire the end product you need. This end product is knowledge, since the startup has to be seen as 'a grand experiment' (Ries, 2011). Commonly, young ventures are part of programmes or communities at which knowledge is freely shared. Most people are probably familiar with the startup incubators.

A third way is to increase the efficiency of the knowledge acquisition process and by those means the reduction the uncertainties. According to Christensen (1997) this could be achieved by focusing on a small customer market and prioritising resources to that. One popular method for increasing efficiency is the Lean Startup method, which is discussed in chapter 2.2.

Figure 2.1-4: a view inside the startup incubator Yes!Delft

2.1.3. Openness to Eco-Design

According to Anderson and Leal (1997), startups show a lot of promise for bringing eco-design into practice. This is attributed to the yet to be developed organisational culture. With the culture still being flexible, the entrepreneurs are more receptive to ideas of environmental sustainability. A study with a range of start-up businesses by Schick, et al. (2002), shows that a majority (7 out of 10 participants) is indeed receptive to the idea of eco-design. However, they have identified four key challenges startup founders encountered: ease of information access, awareness of potential, resources restrictions, support of advisers (Schick, et al., 2002).

Ease of Information Access

The interviewees complained that finding information on the topic of eco-design was troublesome (Schick, et al., 2002). Schaper (2002) found a significant relation between positive ecological performance and the availability of abundant time and environmental knowledge, although it has to be taken into consideration that this research was only conducted with Western Australian pharmacies.
Furthermore, it has to be clear how the information can be easily applied to the processes of the startup (Schick, et al., 2002). Now for the eco-open founders (4 out of 10 participants) there is a disconnect between environmental attitude and actually turning it into action, which corresponds to the findings of Tilly (1999).

Awareness of Potential

The startup founders often don't realise in what ways eco-design could benefit them (Schick, et al., 2002). Currently, besides the small group actively pursuing eco-design, other startups that considered it were mostly incentivised by external pressures (e.g. customers or suppliers). Information about eco-design doesn't clearly communicate how the methods apply to the specific industry of the startup, which results in founders arguing that it is not upon them to tackle the issue of environmental sustainability. Schick, et al. (2002), states that more examples of successful eco-design implementations in specific industries should be made available to the public.

Resources Restrictions

The interviewed founders remarked that dealing with the current workload already is difficult. Attempting an implementation of eco-design could only increase the load, according to them (Schick, et al., 2002). Palmer (2000) found that financial and time resources form the biggest obstacles for following ecological directions. The opinion of the researchers it that this problem could be alleviated with public funding (Schick, et al., 2002). For example the government should set-up more funding for startups pursuing eco-design.

Support of Advisers

Schick, et al. (2002), also conducted research on the openness of business advisers on eco-design. Generally, the advisors advised against following ecological opportunities. They considered an ecological direction for early stage startups as a dangerous choice, since the advisers assume that such practices will have increased costs and a higher risk profile. Only if the benefits (e.g. increased market share, cost saving, financial return) are obvious, they would consider advising on it. However, they also said they didn't regard it as their main responsibility, their focus is at advise for business development.

A similar outcome was obtained for incubators via correspondence with YES!Delft.
On questions relating to the use of eco-design in YES!Delft's programmes for startups, the answer was that eco-design, or aspects of it, aren't taught to startups. As elaboration they wrote, "YES!Delft does not concern itself with product design. At YES!Delft we teach business to engineers. That is why there are no parts of sustainable product development in our programmes." (see full correspondence in Appendix A).
This answer implies a similar stance to the business advisers in that environmental considerations are irrelevant for business development. A stance that they might transfer to the new ventures participating in their programmes. The assumption is that Yes!Delft's stance is representative for the greater startup incubator community, since it was ranked #2 of the world's business incubators in 2018 by UBI Global.

2.1.4. Key Takeaways

Many startups don't succeed (Shane, 2012). A large factor in this failures is the large amount of uncertainties that plague startup companies. Due to the large amount, traditional risk management isn't sufficient (Sommer, et al., 2009) and an experimental approach towards the business model development needs to be taken (Ries, 2011). The experimental approach brings other difficulties. The facets of a business model interrelate to each other, which makes it impossible to resolve the uncertainties of a facet in a vacuum. Because of this resources need to be allocated at multiple locations at once, yet the resources are limited by man-power and knowledge available to the startup. Man-power and knowledge are expressed in units of cost and time. When the cost over time becomes too high the business will have to stop. Three ways of handling the balance between uncertainty reduction through knowledge acquisition and resources are identified:

- generating incoming capital: it counteracts some of the costs of the startup process.
- acquiring knowledge from 3rd parties: reducing your own man-power by getting the knowledge from another party.
- increasing efficiency of the process: making knowledge acquisition more resource efficient.

An application of the third way is the Lean Startup method. From the three, this way is the most often possible, which shows why the method of Lean Startup is so popular with startups.

Startups are also said to be the most promising company form for an eco-design introduction (Anderson and Leal, 1997; Schick, et al., 2002). Nonetheless, startups face some challenges keeping them from engaging with eco-design: ease of information access, awareness of potential, resources restrictions, support of advisers (Schick, et al., 2002).

Ease of Information Access: startup founders have trouble finding and then applying eco-design knowledge to their processes. Having the appropriate knowledge was found to be an essential success factor for bringing eco-design in practice (Schaper, 2002).

Awareness of Potential: eco-design is perceived as not being able to realise benefits for a startup's specific case. This could lead to a person with eco-design knowledge still not applying it. The advise is to provide more case examples.

Resources Restrictions: founders assume eco-design use will increase their workload (Schick, et al., 2002). In addition, financial and time have been found to be the main obstacles to eco-design use (Palmer, 2000). This resonates with the notion that man-power is expressed in cost and time.

According to this an eco-design method shouldn't feel as an extra expenditure of man-power, but as part of the main process, which perhaps could be realised via a Lean Startup introduction.
Support of Advisers: as identified, one of three ways of dealing with the resources is related to knowledge from 3rd parties. Advisers are part of this group. However, they advise against eco-design actions for startups (Schick, et al., 2002). Furthermore, the advisers state their focus is primarily business development, which implies that in their opinion eco-design can't be part of that.

According to this literature, to bring eco-design in the practice of startups, a method should address the following points:

- Focus on the uncertainties of the business model,
- When dealing with uncertainties, they should not be isolated,
- Limited man-hours available for the execution of the tool,
- Limited financial resources available for the execution of the tool,
- Allow for efficient use of resources,
- Knowledge should be easily found,
- Give clarity on the benefits eco-design could offer in a startups specific situation,
- Case specific examples could help startups understand how the method applies to them,
- Use of eco-design shouldn't be perceived as an extra workload,
- Startup is able to explore the opportunities of eco-design without external parties,
- The link between business development and eco-design has to be clarified.

LEAN STARTUP METHOD

The biggest challenge startups face is the lack of certainty. As a startup, you are developing something new from scratch. Many blanks have to be filled in. It is an uncertain, and potentially costly, endeavour to undertake. To reduce uncertainty a method has been developed which was popularised under the name Lean Startup by Eric Ries (2008).

2.2.1. Lean Thinking

As the name implies, the Lean Startup method finds its roots in the mindset of lean thinking. Since its development in the eighties, lean thinking has become one of the world staples on improving efficiency in company processes. This mindset defines 3 types of waste that need to be reduced to improve efficiency (Womack, et al., 1990):

1. Muda: doing work that doesn't benefit the paying customers.
2. Muri: overloading man or machine increases the chance of breakdowns.
3. Mura: lack of flow between different processes.

Already running processes were improved with lean thinking, however the methods based on the mindset weren't suited for new projects, projects such as a startup company. In 2008, on average, over half of startups failed within 4 years (Shane, 2008). In that year Eric Ries came up with the idea for the Lean Startup method, which has as an aim to reduce the amount of projects that fail. This new method is build on 3 principles (Blank, 2013) and a lean mindset.

2.2.2. Three Principles

The Lean Startup builds on 3 principles for execution: business model design, customer development, and agile engineering (Blank, 2013). These three principles have in common that they are methods for business to deal with uncertainty.

Business Model Design

If you want to start a business, the steps you go through are often linear. You write a detailed business plan. With this plan you go to an investor, he assess the risk of the plan and provides you with a loan accordingly. However, startups with a high uncertainty don't fit this mould. There are too many unknowns, thus a business plan based on it most likely won't result

in a loan. Business model design proposes to write hypotheses based on the unknowns, which acts as the preliminary model of the business plan. The most popular tool for this is the business model canvas (Osterwalder and Pigneur, 2010).

Customer Development

This principle is based on involving the customer in business development. A startup with high uncertainty has many unknowns about their business, by means of testing with potential customers these unknowns can be reduced (Blank, 2005). This leads to an iterative learning process.

Agile Engineering

Agile engineering is based on iterative and incremental product development and deployment (Beck, et al., 2001). It stands oppositely of the more traditional development cycle, which could take years before the product launch. Agile engineering strives for launching a product which balances a minimal amount of features while still offering a viable business; a minimum viable product (Blank, 2013). After this launch development continues and new features are offered to customers. This approach allows adaptability to changes in the market, such as customers' needs, which traditional development doesn't (Beck, et al., 2001).

2.2.3. Learning Loops

The Lean Startup method brings the 3 principles (business model design, customer development, and agile engineering) together with a focus on iterative learning. The method propose a validated learning loop (figure 2.2-1) existing out of 3 phases: build, measure and learn (Ries, 2011).

Build

The loop starts with a business model, which is filled with hypotheses. These hypotheses need to be ranked based on how fundamental they are to the business model. More fundamental hypotheses have more impact on the direction of the startup, especially when they are disproven. This process is called innovation accounting. Since the hypotheses need to be tested, they need to be written as measurable statements, similar to the scientific method.
With a combination of hypotheses an early version of a product is build, which needs to be minimal viable product. There is no need to have a polished product. Testing is the main goal of this version.

Measure

A minimum viable product and a test setting have been created. Now the aim is to find real potential customers to do tests with. If these potential customers are positive about the product, there

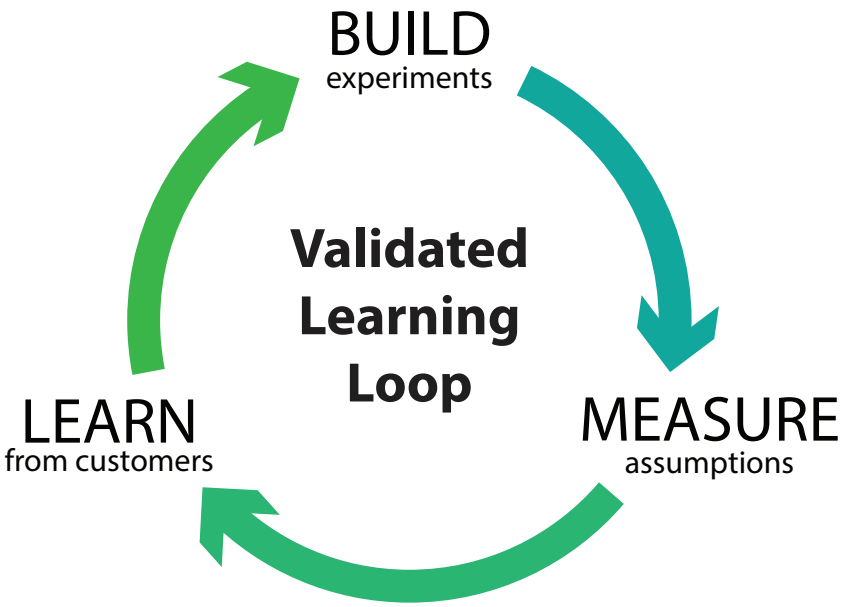


Figure 2.2-1: the validated learning loop made with the Lean Startup method.

is a real shot of the product becoming a success. Nonetheless, a disproven hypothesis will be as helpful as a proven one for reducing the uncertainties in the startup's business model. To quote Ries (2011): "Every setback is an opportunity for learning how to get where they want to go."

Learn

The learning phase starts with analysing the data output of the customer testing. The data needs to be transformed into insights useable for further product development, and insights understandable for the startup team members that didn't execute the testing. By means of reflection the product and business model are adjusted, and the adjustments become new input for the next iteration through the phases of build, measure and learn.

2.2.4. Cycle Efficiency

Since the Lean Startup method is grounded in the lean mindset, the aim of the method is not to execute the 3 validated learning phases, but to do so in an efficient manner. This is expressed in the statement about the focus of the method (Ries, 2011): "providing benefit to the customer; anything else is waste.". Ries (2011) expands on this by writing that anything that doesn't give learnings should be removed. The unit of progress of startup should be measured in how much is learned. Yet Maurya (2010)* states that learning shouldn't be the only focus. A harmony needs to be established between learning, speed and focus (Figure 2.2-2) to realise the optimal validated learning loop.

* 2010 is a year earlier than Ries' publication of The Lean Startup (2011). However, Maurya was still able to base it on the work of Ries, since the first publications about the Lean Startup method were online starting from 2008.

Speed

In chapter 2.1 it was established that the startups are in a constant race against the clock. A young venture's resources (e.g. cash, manpower) are running out over time. They want to find results that will replenish the resources and extend the time they have. With an increased speed through the learning loops, such results will be reached quicker.

Learning

As the famous quote attributed to Henry Ford, "If I had asked people what they wanted, they would have said faster horses.", illustrates; the customer's opinion isn't always helpful for business development. Customer research should not directly become input for a follow-up iteration, because there will be a lack of learnings. In this situation not enough adjustment to the startup's hypotheses has been made, which results in 'chasing your tail' (Maurya, 2010). Time needs to be taken to transform the data into meaningful changes to the business model, so the learning loops are plentifully different.

Focus

A focus during the validated learning helps as a guide for determining meaningful transformations of customer data. Without a focus a viable business plan might be achieved, however it doesn't have the full potential it could have had. There is premature optimisation.

The focus is often expressed with the startup's vision. A vision is an idealistic outcome envisioned by the startup founders, which is not necessarily realistically achievable, but sets the framework the startup will operate in (Ries, 2011). For example, if your vision is centred around teaching African children, you won't end up making a better camping experience. With a vision as the guide, a startup can create a truly innovative business (Ries, 2011), which results in a high competitive advantage.

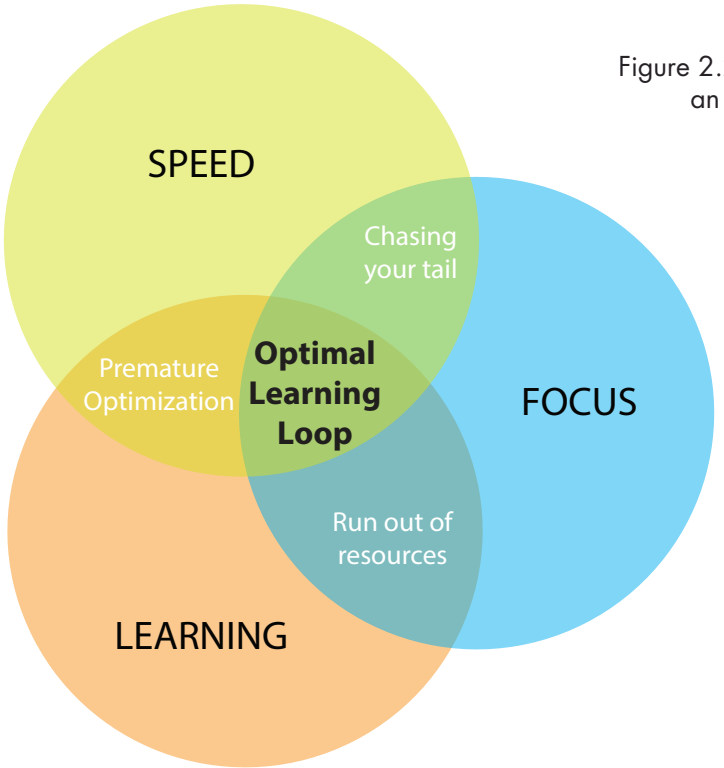


Figure 2.2-2: Venn-diagram of the elements to create an efficient learning loop with the effects if an element is absent (Maurya, 2010)

2.2.5. Key Takeaways

Startups with a high level of uncertainty can't rely on traditional business plans, because of the many unknowns. Although, it can be captured in a business model by stating it as hypotheses (Osterwalder and Pigneur, 2010). An effective way of validating hypotheses is by means of customer testing (Blank, 2005). Ideally, testing is done iteratively, since it allows more adaptability to the market (Beck, et al., 2001). Incremental product development and deployment leads to minimum viable products, so customers can test with the product itself (Blank, 2013).
The Lean Startup method proposes a framework of 3 phases (build, measure, learn) that are iteratively repeated to enable an increase of efficiency in the validation of hypotheses with customer research (Ries, 2011). With in this framework the main unit of progress for a startup becomes how much they have learned. The hypotheses have to be written a measurable statements to assess if learning have been gained.
The efficiency of the iterative validations is dependent on the harmony between speed, learning and focus (Maurya, 2010). Speed is necessary for resource efficiency per loop. Learning requires making meaningful adjustments to the hypotheses to gain the most of each validation loop. Focus functions as a guide, based on the startup's vision (Ries, 2011), to establish what meaningful adjustments are.

According to this literature, for an introduction via the Lean Startup method, a method should address the following points:

- Focus on removing business model uncertainties,
- Allow for input in the form of measurable hypotheses,
- Focus on gaining insights from customers,
- Allow for output to be shaped in measurable hypotheses to be tested,
- Allow for iterative usability,
- Allow for short-term validation loops,
- Allow for critical reflection on the data output,
- Enable the expression of the startup's vision.

2.3 Literature

ECOLOGICAL DESIGN

The adoption of eco-design into business practice has been slow (Baumann, et al., 2002). The threshold for startups to adopt eco-design is the combination of unclear benefits and assumed introduction cost (Schick, et al., 2002; Nidumolu, et al., 2009). The Lean Startup method potentially could offer startups the chance to discover the benefits of eco-design without high cost. However, there also appear to be some frictions between eco-design and the Lean Startup that need to be addressed in order to get the two to function together. This chapter kicks off by discussing these frictions. Secondly, a focus is set to determine the benefits eco-design could offer, which followed-up with the potential barriers eco-design still can have within this focus.

2.3.1. Frictions

The perceived friction between eco-design and the Lean Startup method is not an unexpected phenomenon. The core of the approaches seem to lie miles apart. The Lean Startup method, as discussed in the previous chapter, deals with the uncertainties of a new business model by aiming on a small customer centred focus (Blank, 2013). Eco-design methods on the other hand ask for a lifecycle perspective (Lindahl, 2005). It is a cycle from resourcing materials until the remnants of a product return to the ground again (figure 2.3-1). A cycle on which the customer is only a small part of the focus. Can these differing focuses function unitedly?

Holistic Approach

Ceschin and Gaziulusoy (2016) identify nine approaches for environmental sustainability. For each approach there are many eco-design methods possible, however each approach comes with some limitations. As a result focusing on a single approach is often not sufficient to reach environmental sustainability. There is even a chance that it will result in shifting the ecological impact to somewhere else on the lifecycle (Ceschin and Gaziulusoy, 2016). Similarly, it is found that for a business that wants to go sustainable it is often not enough to focus on aspects such as new product development or refining the operations of a company alone. A holistic value system change is required, which is achieved via business model innovation (Chesbrough and Rosenbloom, 2002;

Zott and Amit, 2010; Rashid, et al., 2013). The results is a sustainable business model (Geissdoerfer, et al., 2017).
Chapter 2.1.2 also concluded that a holistic approach is a necessity for the business development of a startup. This followed from the finding that the uncertainties of a business model are interrelated. It is resource intensive to deal with many uncertainty simultaneously, which is why methods like the Lean Startup are employed.

These relations show that eco-design can be linked to the Lean Startup method, since the method helps deal with the resource intensity of executing a holistic business model approach, which is an approach that allows for a well-rounded application of eco-design. However, this does not yet address the customer centred focus the Lean Startup takes (Blank, 2013).

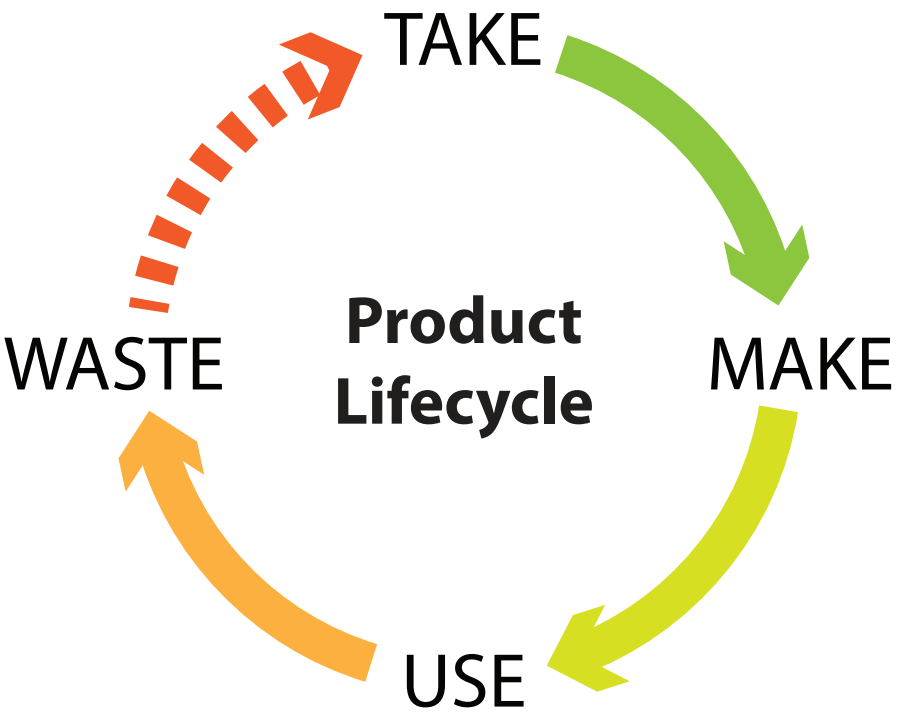
Focus Group

Ries (2011) writes that the focus of the Lean Startup is that anything that is not benefiting the customer is waste. In contrast, the focal point of the sustainable business model is a multitude of stakeholders (Geissdoerfer, et al., 2017). The sustainable business model is characterised by (Geissdoerfer, et al., 2017):

- pro-active management of multiple stakeholders,
- creating value, monetary and non-monetary, for the stakeholders,
- a long-term perspective.

What is similar is that both methods want to provide benefits to their respective focus groups, however the motivations are different. For startups creating benefit for customers is the most direct way of getting profit returned to the company, which they need for their company survival (Ries,

Figure 2.3-1: visualisation of the product lifecycle. In reality not all aspects are of the same duration or impact on the life.



2011). The goal of sustainable business models is achieving a holistic lifecycle perspective, and benefits need to be created for all stakeholders for them to be willing to participate (Tyl, et al., 2015). Based on these motivations two ways to unite eco-design and the Lean Startup can be distinguished:

1. The company can profit from multiple stakeholders, which effectively means that the company has multiple customer groups.
2. Extra stakeholders are only included in the business model if their contribution benefits the customer.

Although, in either way the chance of a complete lifecycle perspective being reached is low, since it is unlikely that every stakeholder can offer benefits to the customer or company.

Execution

Eco-design and Lean Startup are also perceived to differ in execution. Eco-design is seen as a long-term plan (Nidumolu et al., 2009), while the Lean Startup method favours a fast iterative development process (Maurya, 2010). The statement about eco-design is confirmed with a characteristic of the sustainable business model being a long-term perspective (Geissdoerfer, et al., 2017). However, Plouffe, et al. (2011), found that eco-design is actually profitable on the short-term, which would help fuel the iterative process of lean startups. They found that sales volumes and revenues are higher for eco-designed products. A higher success rate was also discovered for small and medium-sized enterprises compared to corporations, and success increased with companies applying lifecycle thinking (Plouffe, et al., 2011).

The takeaway is that the frictions between eco-design and the Lean Startup method aren't as strong as they are perceived to be. There are some opportunities that can be exploited to create connections between the approaches. The main objective is to create benefits for the company, which largely comes by creating value for the customer, to interest lean startups in eco-design.

2.3.2. Benefiting

Previous section established the key importance of benefits for compelling lean startups to use eco-design. Fittingly, there is an increasing agreement that eco-design can be a source of competitive advantage (Nidumolu, et al., 2009; Porter and Kramer, 2011b). Stevels (2002) presents five different ways a company can implement environmental sustainability and profit from it. He expresses the benefits in three level for four groups. The groups are company, customer, society and environment. The levels are:

- material; benefits directly related to extra income or cost reductions,
- immaterial; improvement on processes, such as simpler production,
- emotional; positive feelings, such as a less guilty conscious.

However, Stevels does not state all aspects with the same transparency, which makes it a bit open for interpretation. The five ways of creating profit are: eco-design, marketing & sales, suppliers, paradigm shift, quality level.

Eco-design

Not to be confused with the general use of eco-design in this report. Eco-design in this categorisation is mainly related to the materials used. Next to the bill of materials, this relates to aspects energy impact of the product, transport cost, volume discount.

Marketing & sales

Only a small percentage of customers is actually interested in environmentally friendly products (Stevels, 2002), however applying eco-design create other benefits like lower prices for the customer, which would be a good way to attract customers. This aligns with other researchers that offering only the extra of environmentally sustainability is often not enough (Plouffe, et al., 2011). The marketing benefit of eco-design can also relate to attracting stakeholders, for example universities wanting to work together or new kinds of investors.

Suppliers (and stakeholders)

Stevels (2002) focuses on suppliers, but it can be related to any stakeholder in your value chain. The idea is that when a supplier decreases cost by applying eco-design, it will probably benefit both of you. Because of this the suggestion is to give more freedom to suppliers to allow them to change the designs.

Quality Level

The main benefit to achieve with this path is a reduced number of products rejected. Hinkley (1999) showed that the best way of achieving this is by reducing design complexity. For a product this can be achieved by making the design simpler or reducing the amount of materials. Next to that the assembly and production process can also be simplified. For example by looking at modular design for easier assembly.

Paradigm shift

The concept of paradigm shift is rethinking the status quo. Some processes might be taken for granted over time, but with a new angle could actually become much more efficient. For a product this manifests in putting function over form. For example, a battery powered object might become human-powered, but also instead of selling a product one could shift to a service model.

Sustainable Business Benefits

The five ways Stevels (2002) defined address a broad range: stakeholders, business models, value chains, product design, manufacturing and material sources. Together these aspects address many of elements for a sustainable business model approach. There is one notable absence, which is profiting from product end-of-life.

2.3.3. Barriers to Eco-Design

Unfortunately, offering an abundance of benefits is not enough to convince most companies to use eco-design. The benefits need to outweigh the negatives, and startups do currently experience multiple barriers towards executing eco-design (Schick, et al., 2002), which is discussed in chapter 2.1.3. In this sub-chapter the focus is on barriers inherent to eco-design methods, which starts with the complexities of a lifecycle perspective.

Quality Level

Looking at for example all the components in your phone, you can imagine how many material paths are involved of a lifecycle of a single product, let alone the complexities of complete business model. Sources of lifecycle complexity are (Brundage, et al., 2018):

- multi-dimensional nature of the associated metrics,
- interconnectedness of social and economic influences on sustainability,
- difficulty in anticipating user behavior,
- connected data comes in contrasting forms.

Furthermore, the information needed to deal with the complexities mostly unfolds as the product develops. Because of the missing data (Ramani, et al., 2010), it is difficult to accurately use eco-design in the early design phases. However, implementation of environmental sustainability will become more difficult in later stages (Herstatt and Verworn, 2001; Bocken, et al., 2014) and is susceptible to higher rates of failure (Geissdoerfer, et al., 2016). Because of this paradox, the implementation of sustainability in design has largely remained an expert driven practice (Brundage, et al., 2018), and Bernstein, et al. (2010), demonstrated that even expert designers face difficulties in deciding on redesigns. These difficulties are a result of (Ross, et al., 2002):

- Poor data quality,
- Incorrect assumptions,
- Non-transparent assumptions,
- Poorly documented assumptions.

It is increasingly argued (Lindahl, 2005; Hallstedt, et al., 2013) that eco-design introduction should be aimed at the early design phases for a successful implementation. This goes paired with notion that the focus should move towards better communication of data (Borsboom, 1991; Hallstedt, et al., 2013; Brundage, et al., 2018). Boks (2006) suggest to use environmental checkpoints or milestones, which can support in securing the quality of the communication.

Identification

A barrier to eco-design often highlighted is the extra resources it will cost. Acquiring the data for a lifecycle analysis will cost man-power or cost of purchase from another party (Rossi, et al., 2016). Yet, I argue this is not specific to eco-design. Any new method, which is not a replacement of an old system, will require extra

resources in the early phases. What is important is the size of this investment compared to outcome, which is why researchers suggest that opportunity identification is of key importance for eco-design (Herrmann et al., 2008; Volkmann et al., 2009; Lourenço, et al, 2012). According to, Hallstedt, et al., (2013), more tools should guide decisions instead of only providing assessment.

Usability

Another barrier of eco-design methods is caused by how the methods are conceived. Most come from academics, who don't take the needs of the users sufficiently into account (Rossi, et al., 2016). The users are often not the academics themselves.

Boks (2006) argues that there is plentiful knowledge on eco-design, and that the focus should shift to making it easily available and useable for the right people. Santolaria, et al. (2011), back up that the ease of access should be increased, even adding that free tools should be made available. Rebitzer, et al. (2004), argue the aim should be method that are simple to use by non-expert.

Figure 2.3-2: end-of-life of product is not well-addressed yet.

2.3.4. Key Takeaways

The Lean Startup method and eco-design have different approaches, which brought forward the question if there can be some unity between the two. Some areas to link them have been identified. A proper use of eco-design needs a holistic approach, which can be realised with a sustainable business model (Geissdoerfer, et al., 2017). Similarly to startups, this brings uncertainty and pressure on the resources, which the Lean Startup method is aimed to resolve (Ries, 2011). However, the sustainable business model has a multi-stakeholder perspective (Geissdoerfer, et al., 2017), while the Lean Startup just wants to benefit the customer. Two possible outcomes are identified:

1. The company can profit from multiple stakeholders, which effectively means that the company has multiple customer groups.
2. Extra stakeholders are only included in the business model if their contribution benefits the customer.

Execution approaches also seem to be misaligned, since the Lean Startup method favours fast iterative development process (Maurya, 2010), while a sustainable business model should have a long-term perspective (Geissdoerfer, et al., 2017). In spite of this, Plouffe, et al. (2011), showed that eco-design can actually also be profitable for a company on the short-term, meaning a startup could main short cycles, while planning the long-term.

Stevels (2002) identified 5 ways of achieving benefits for customers and company by means of eco-design. These range of the eco-design interventions come close to a holistic approach. Notably absent is how end-of-life scenarios can be beneficial.

Some barriers inherently to eco-design were identified. The main one being the complexities of doing a holistic lifecycle approach (Brundage, et al., 2018). Data for taking the approach becomes available in the progression on the development, however

implementing eco-design in later stages has been showed to be difficult (Herstatt and Verworn, 2001; Bocken, et al., 2014). As a result the aim is to use eco-design from the early design phases (Lindahl, 2005; Hallstedt, et al., 2013) and aim for better communication (Borsboom, 1991; Hallstedt, et al., 2013; Brundage, et al., 2018) to forgo the difficulties the data might create (Ross, et al., 2002).

Furthermore, the focus should be moved away from the potential costs of an eco-design introduction, towards an opportunity identification by users (Herrmann et al., 2008; Volkmann et al., 2009; Lourenço, et al, 2012). Next to that, eco-design should be more tailored to the actual users (Rossi, et al., 2016), not to the academics. The barrier of access for these users should be lower (Santolaria, et al., 2011), and it is even suggest to make it simple to use for non-experts (Rebitzer, et al, 2004).

According to this literature, for an introduction via the Lean Startup method, a method should address the following points:

- Take a sustainable business model approach,
- Outcomes should benefit the customer in some form,
- Ideally the method allows for short and long-term approaches,
- Application of the method should be to early design phases,
- It is beneficial if the method applies lifecycle thinking (Plouffe, et al., 2011),
- Improve documentation on data assumptions (Ross, et al., 2002),
- The data output from the method should be easy to communicate,
- It is beneficial if the method allows for setting environmental milestones (Boks, 2006),
- The method should allow users for their own opportunity identification,
- Language of the method should be aligned with the end-users,
- It is beneficial if the method can be used by non-experts,
- It is beneficial if the method can be used for guiding eco-design decisions (Hallstedt, et al., 2013).

2.4 Literature

MEANS OF INTRODUCTION

The introduction of a method into the processes of a running company can generate some frictions, due to new and old system not fitting one to one (Mariano and Casey, 2015). This chapter explores first how a newly introduced method could better fit with the current processes. Secondly, a potential user needs to be convinced the method is applicable to his situation. Eco-design is perceived as having contradicting features with the Lean Startup method. With this presumption, a startup potentially could immediately disregard an eco-design method.
After the usefulness of a method has been accepted, it would be ideal if practicing eco-design will lead to a repeated practice, which is explored in the last sub-chapter.

2.4.1. Unite Current & New

Innovation is generally seen as a positive change, however it is argued innovation could impact an organisation negatively (Mariano and Casey, 2015). Mariano and Casey (2015) identify the incompatibility between newly introduced knowledge with knowledge currently present in the company as the cause of the negative impact. This incompatibility could cause internal disruptions resulting in time loss and increased costs (Zhao and Olivera, 2006). As Schick, et al. (2002), found, startup founders aren't actively putting eco-design into practice, because of the increased time and costs associated with it (further reading in chapter 2.1.3). Arguably this is a result of the incompatibility between eco-design methods and the current processes of startups, such as the Lean Startup method.

Recognise & Reformulate

According to Mariano & Casey (2015), incompatibility between newly introduced knowledge and current processes can be recognised by the reactions of employees on the new knowledge. These reactions are for example avoidance or resistance, as shown in Table 2.4-1. Since the incompatibility has negative effects, it is key to identify it early on, after which conflicts can be removed by means of reformulation (Mariano and Casey, 2015). There are three levels of reformulation (shown in Table 2.4-1), which can be selected based on the

size of the incompatibility. However, Mariano & Casey (2015) don't provide an indication of how the level can be identified.

I also argue that recognition of incompatibilities after introduction is late. The idea of potential negative consequences could result in potential users refraining from trying a new method. I propose that the incompatibilities could be identified before introduction by means of testing with the target user group; startups.

Boundaries & Transitions

The level distinctions of the proposed method by Mariano & Casey (2015) is unclear. Carlile (2004) proposes a model with clearer distinctions. His method recognises knowledge incompatibilities by determining the knowledge of multiple actors and comparing the differences in knowledge between them.
The model (Figure 2.4-1) identifies three boundaries between levels of knowledge (syntactic, semantic, pragmatic), which all have a distinct process to pass through (respectively: transfer, translation, transformation) (Carlile, 2004).

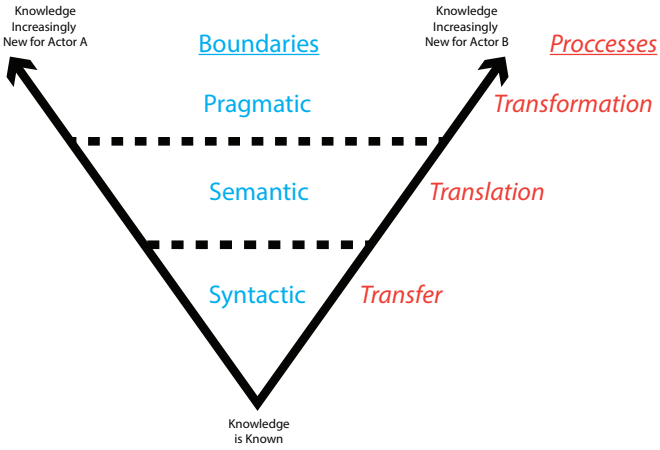


Figure 2.4-1: Boundaries in Knowledge based on the perspective of 2 actors (Carlile, 2004).

In the first level 'syntactic' both parties have a similar understanding, thus information can easily be transferred. For example, one places information on a storage and the other actor retrieves it. In the 'semantic' level some translation is required between the actors. Through interactions the parties create a common meaning of the knowledge. With iterations the knowledge moves to being known by both parties. At the 'pragmatic' level the understanding of the knowledge between the actors differs greatly. To bridge the gap the knowledge needs to be transformed by putting a so called 'boundary object' (Star, 1989; Carlile, 2002) between the actors over

Action	Elements	Organisational Outcomes
Recognition	Avoidance Restistance Struggle Alteration Conversion	Decrease absorption and learning Increased knowledge dissipation Decrease organisational performance
Reformulation	Minor adaptions Creative reformulations Changes in knowledge introduction methods	Increased adoption and learning Decreased knowledge dissipation Increased organisational performance

Table 2.4-1: How to recognise and reformulate an incompatibility between knowledge (Mariano and Casey, 2015).

which they can negotiate to establish an understanding.

Based on the descriptions the assumption is that the methods (Carlile, 2004; Mariano and Casey, 2015) relate to each other as shown in table 2.4-2. I argue that an introduction of eco-design to startups is generally so much new knowledge to them that it reaches the top boundary: pragmatic. Carlile (2004) states that one has to go through all boundaries to resolve knowledge incompatibility. This means executing all reformulation actions. For the pragmatic boundary a boundary object is required as well. This could be an ideal placement for a new tool. However, a negotiation between actors isn't deemed viable, since it would require a lot of man-hours for the introducer of the knowledge to service all startups that want acquire the knowledge. To resolve this the assumption is made that providing transparency on the origins of the newly introduced knowledge and the creation of the boundary object allows startups to have the negotiation without another actor. For this situation the other two boundaries are already removed, wearing the boundary in advance.

2.4.2. Convince of Benefits

New knowledge that could bring positive changes to the established system, doesn't always get accepted. This is not just an effect of misunderstanding the knowledge, as discussed in the previous sub-chapter, the cause is the strong commitment someone has to the current system.

Escalation of Commitment

People being averse to change is not an uncommon phenomenon. But escalation of commitment becomes truly visible when someone keeps a trajectory, even though all the information overwhelmingly goes against it. This behaviour has also been observed within companies.

Test results show the effect of escalation of commitment is in particular strong with managers that initiated a project, compared to managers placed were placed on a project in a later phase (Schmidt and Calantone, 2002). These results are relevant since a startup founder can be considered similar to a manager initiating a project.

The test outcomes also showed that managers of a new product development project are much likelier to keep committing to the direction,

Boundaries	Boundary Processes	Reforumlation Actions
Syntactic	Transfer	Minor adaptions
Semantic	Translation	Creative reformulations
Pragmatic	Transformation	Changes in knowledge introduction methods

Table 2.4-2: Writer's assumption on how the methods of Carlile (2004) and Mariano and Casey (2015) relate to each other.

than managers who manage a product that has been commercialised. In addition, Berchicci and Bodewes (2005) showed that a project with an environmental mission can cause a decision maker to commit to the project while the new knowledge says otherwise as well.
Schmidt and Calantone (2002) write that the escalation of commitment can't be simply countered by clearly presenting all the facts to a manager. One suggestion is to change the perspective of the manager by means of reframing (Dorst, 2015), which would open the manger up to new information.

Reframing the Commitment

To get a manager to objectively overlook the information, he needs to be pulled out of his current frame of reference. A manager has such a frame to deal with complexity of the situation. As discussed in chapter 2.1, there are many uncertainties in the development of a startup, and often these uncertainties are interlinked. Furthermore, a startup is limited in the resources it can allocate to deal with these uncertainties. These factors of managing uncertainty create a complex situation (Sommer, et al., 2009). The frame a manager has is a set of boundaries set to reduce the complexity of the situation (Dorst, 2015). The challenge is that most people don't see that they themselves put these boundaries in place and are not inherent to the situation. A group that is natural at observing the boundaries and reframing them are expert designer (Dorst, 2015). Their practices can be reused for others to achieve similar results. This is called the frame-creation process (Figure 2.4-2). A process with nine steps, which changes a frame by deconstructing the situation and building a new frame. If a startup founder would go through this process with the newly acquired knowledge about eco-design, it would most likely result in a high acceptance of the new information.

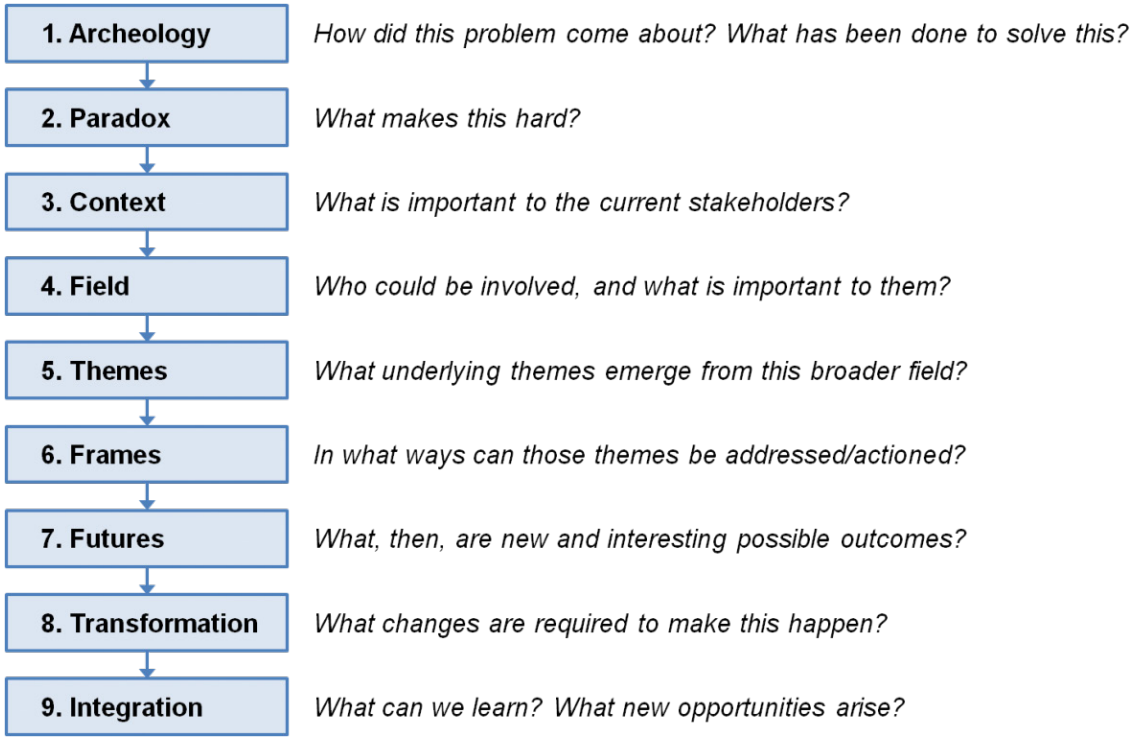


Figure 2.4-2: Steps of the frame-creation process (Dorst, 2015).

2.4.3. Repeated Use

Startups are hesitant in using eco-design methods, because of which it is reasonable to assume that they won't directly convert their entire business to become environmentally sustainable when they discover some of the benefits that eco-design offers. Nudging the startups to repeatedly use eco-design methods could eventually achieve a similar outcome. This sub-chapter discusses how such repeated use could be achieved.

Activate Use

Fogg (2009) describes three elements that together determine the likeliness of a person undertaking an activity: motivation, ability, and trigger. First an action line has to be crossed by the combined balance of motivation and ability (see figure 2.4-3) This line is an inverse relation between the strength of the motivation and difficulty of the ability required. Once the action line is crossed, the trigger is the final spark that set the person to action.

Motivation

A person's motivation is the reason a person takes certain actions. Motivation can be divided in intrinsic and extrinsic (Ryan & Deci, 2000). Extrinsic motivation is commonly associated with positive rewards, but it can be caused by any external pressure. This means the motivation could also be related to pressures such as punishment, competitive threats, or deadlines. Contrarily, intrinsic motivation comes from aims you have internalised in your mind. Extrinsic motivation is better suited to kickstart activity, while intrinsic motivations excels at pushing for activity over a longer timespan. Since extrinsic motivation requires providing a reward, a longer span could also prove unsustainable due to the sum cost of the rewards, and the value of a reward could change over time. However, moving the motivation for an activity from extrinsic to intrinsic could prove difficult as well, because extrinsic motivation is known to undermine intrinsic motivations (Ryan & Deci, 2000).

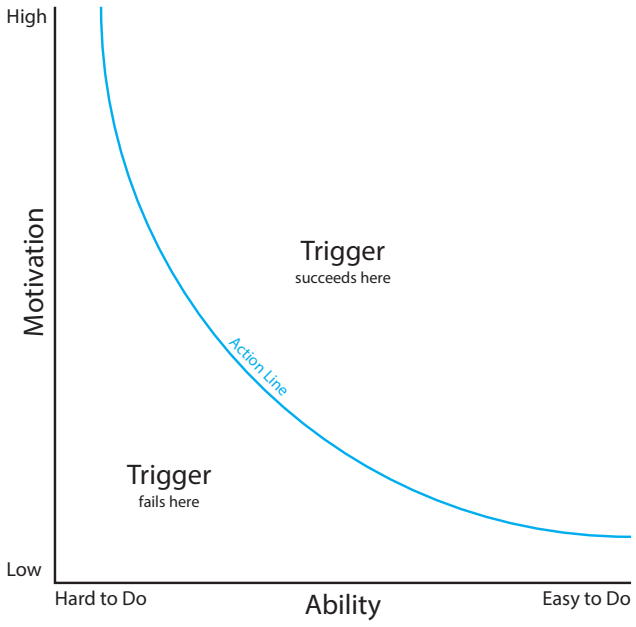


Figure 2.4-3: Behavior Model, which shows the relation between motivation, ability and triggers (Fogg, 2009).

Ability

Ability is affected by a person's state of being and the situational context. The state of being refers to the combine mental and physical capabilities (Fogg, 2009). As an example of how these capabilities are like to each other, the lack of knowledge about eco-design can be seen as part of the mental capabilities, while the physical capabilities like the man-power available could be set to work to find where to acquire the knowledge. The situational context is about the setting the activity needs to take place in (Fogg, 2009). For example, the situation could make it more difficult for a startup to take an eco-design action by not setting up any environment related funding systems.

Trigger

The trigger is the last push need to start an action. Often this is like a reminder. This could be in the forms like a notification, an association, or a pattern. Triggers can be planned by a persons to set themselves to action, or could be unexpected when some change in the environment sparks the mind (Fogg, 2009).

Repetitions

From the three elements, motivation is the most critical for the success of repetitions. Ability and trigger can be planned. For example, to increase the ability the amount of knowledge can be increased and to trigger reminders can set. However, for motivation only extrinsic motivation can be planned and the strength of this form is known to decrease over time. This also happened for early ecodesign, when the benefits became marginal after the first major inefficiencies of a product design were removed (Ceschin & Gaziulusoy, 2016). Another fact to take into account is that in chapter 2.3.2. it is established that an introduction of eco-design for startups is most likely to succeed by offering competitive benefits to a company. In the classification of Ryan & Deci (2000) this is considered an extrinsic motivation. The use of extrinsic motivation to systematically activate startup to use eco-design seems unavoidable. Since it is difficult to achieve intrinsic motivation when extrinsic motivation has been used (Ryan & Deci, 2000), I would argue that the only path to repeated use of eco-design seems to be the prevention of the diminishing strength of extrinsic motivation over time.

2.4.4. Key Takeaways

This chapter discussed three phases a newly introduced eco-design tool needs to go through. The first step is to make the content of such a tool fitting with the current processes existing within the company. If this isn't done, it could lead to internal disruptions (Zhao and Olivera, 2006). Which means that the incompatibility should be recognised early on and the content of a tool should be reformulated accordingly. My suggestion is to reduce the incompatibilities before a tool is deployed, which can be achieved by testing the tool beforehand with target users. But only a reformulation is not sufficient because of the size of the gap of knowledge between the startups and the field of eco-design, according to Carlile (2004). A boundary object is required that facilitates a negotiation between parties (Star, 1989; Carlile, 2002). A new tool could fulfil the role of a boundary object, however negotiations aren't deemed viable, because it would require a party that introduces eco-design to startups, which is costly. Furthermore, establishing such a party is seen as outside of the scope of this project. The assumption is made that providing transparency on the origins of the newly introduced knowledge and the creation of the boundary object allows startups to have the negotiation without another actor.

Nonetheless, even when knowledge about eco-design would be fitting with the current processes of startups, there can be the barrier called escalation of commitment. This effect, addressed in the second phase, makes people reject new information even though all signs show it should be applied. It does not effect everyone, although sources show that startups have a higher likeliness to be affected (Schmidt and Calantone, 2002). If someone is affected, presenting all the facts isn't enough to counter it (Schmidt and Calantone, 2002), but reframing the situation would (Dorst, 2015). Reframing can be achieved with the frame-creation process (Dorst, 2015).

The third phase is based on the assumption that there probably should be repeated use of eco-design methods, because currently startups are hesitant in using eco-design, which makes early applications likely to be incremental. Fogg (2009) describes three elements that activate people to do something, which in the right setting could lead to repeated activity. From the elements, ability and trigger, can be planned. A trigger could be in the form of a notification or a pattern. The ability is based on the mental and physical capabilities of the user and the context the activity should take place in (Fogg, 2009). The third element, motivation, is more difficult to control. Intrinsic motivations differ per mindset of a person, making it difficult to apply to a broad group. Extrinsic motivation is controllable because it takes the form of reward systems (Ryan & Deci,

2000), but the strength of its effect can diminish over time. However, since chapter 2.3.2. also established that the extrinsic motivation of competitive benefits is most likely to realise a successful eco-design introduction, I argue that the aims should be the prevention of the diminishing strength of extrinsic motivation over time.

According to this literature, for an introduction of eco-design, a method should address the following points:

- Content is reformulated to fit the current context of startups,
- Origins of the newly introduce knowledge in the method should be transparent for others,
- Creation of the method should be transparent for others,
- It is beneficial if the Process of the method is (partially) aligned with the frame-creation process,
- Prevention of the diminishing strength of extrinsic motivation over time,
- Establish a trigger to activate someone to use the method,
- Give a user sufficient knowledge to provide the mental capability to activate use,
- Make the mental capability for use low,
- Make the physical capability for use low,
- Preferably the ability of use is unrelated to contextual elements.

3 USER RESEARCH

The literature study has provided insight on how eco-design can be brought into startup practice, yet many directions are still open. Within this project the focus is created based on a Lean Startup approach, meaning an iterative and customer centred approach. The aim of this user research is to narrow down the focus of the benefits interesting for startups and to discover more specific requirements the startups would give to an eco-design tool. These two topics are connected by a conversation about the current operational processes of the startups. In total the input of 5 startup founders has been gathered and analysed.

INTRODUCTION

A core barrier for startups to practice eco-design is that the benefits of it are unclear (Schick, et al., 2002; Nidumolu, et al., 2009). The literature study established some direction in this by means of the fundamentals startups require and the benefits eco-design can offer. However, according to principles which the Lean Startup method follows success can be increased by focusing on a smaller target group in the first phases (Christensen, 1997). This research aims to discover more specific benefits that are interesting for early phase startups.

The second topic of this research is a further exploration of the opposite of the benefits; the barriers to practicing eco-design. The literature study has established that startups are limited in their processes by the extend of the fundamental resources: knowledge and man-power Chapter 2.1.). Next to that, practicing eco-design itself has some barriers (Chapter 2.3.). But like with the benefits, the range is broad, and a focus to a target group is preferable. The aim is to detect barriers to eco-design for early phase startups and to transform those to criteria for an eco-design tool.

As connective tissue between the topics, the current operational processes of the startups are a point of discussion. Such processes often show aspects of both benefits and barriers, because the processes are applied to achieve certain goals which contain benefits, while when the operations aren't unfolding as envisioned, it shows barriers the startup encounters. In addition, it is easier for people to talk about abstract topics (benefits and barriers) by linking it to their own experiences (Patton, 2002), which are the operations of the startup for a founder.

Relations between the User Research topics

Figure 3.2-1: quick overview of how the topics adressed in this research relate to each other.

Figure 3.2-2: Logo's of the five startups that participated.

3.2 User Research

METHOD

For this empirical study five conversations with startup founders have been held (Appendix A.1: profiles of the founders and startups). The startups are selected with the following criteria:

- Startup does not exist for longer than 12 years (based on Shane, 2012; Ch. 2.1.1).
- Startup has a business model with high uncertainty (based on Ries, 2011; Ch. 2.1.1).
- Startup works with the Lean Startup method (method is detailed in Ch. 2.2.).
- Startup's business development is in the early design phases (Ch. 2.3.1. eco-design implementation is most likely to succeed during these phases).

Semi-structured interview guides are created to steer the conversations. Two guides have been made to increase the potential of useful data and insights (appendix A.2. and A.3.). Both guides have a similar beginning and end. First an introduction of the startup to have the founder open up. This is followed by going into the operational processes and tools used within the startup. The middle contains a conversation about existing tools with a relation to the eco-design introduction via the Lean Startup method. The end of the interviews founder's views on eco-design.

The changes in the guides exist out of some minor and major ones. Minor adjustments have been made to elicit some more in-depth insights. Extra probes have been added and the processes section is expanded with questions about acquiring new knowledge.
The major variation is tools addressed in the middle section of the guide. The first guide (appendix A.2) aimed at getting the opinion of founders on some tools that have potential for giving some touch points for bringing

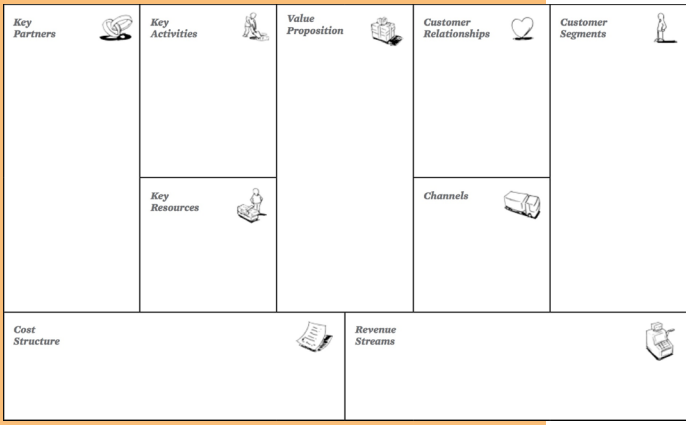


Figure 3.2-3: business model canvas by Osterwalder & Pigneur (2010).

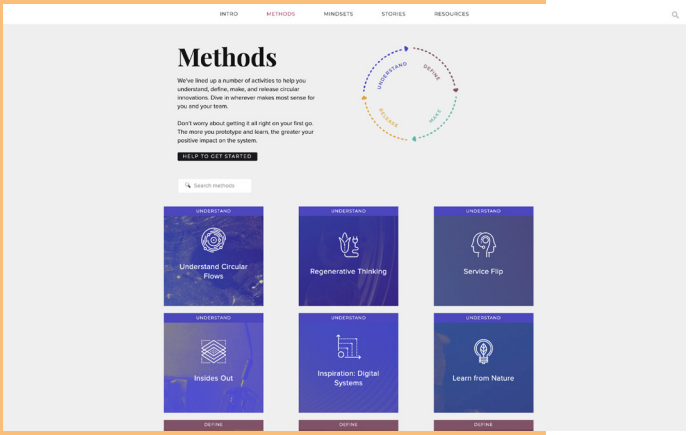


Figure 3.2-4: Screenshots of the Circular Design Guide (IDEO, 2017, www.circulardesignguide.com)

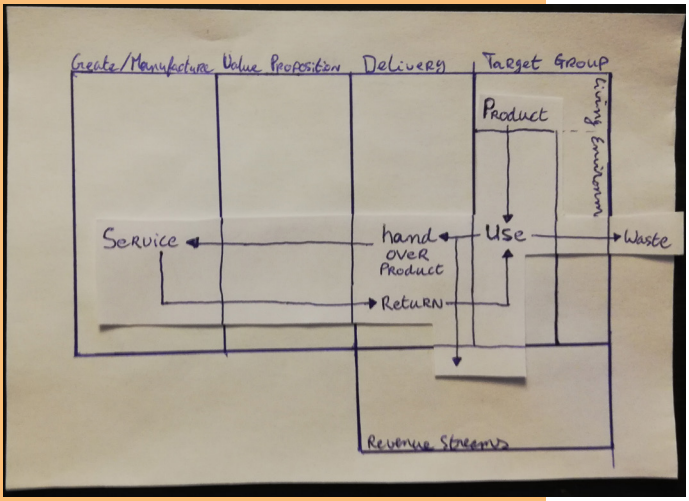


Figure 3.2-5: Simplified business model canvas with one of the circular stategies placed on top of it.

eco-design into practice. The tools used are Business Model Canvas (Osterwalder and Pigneur, 2010) and the Circular Design Guide (IDEO, 2017, www.circulardesignguide.com). The Business Model Canvas (see Figure 3.2-3) was chosen since it is a concrete expression of one of the three principles behind the Lean Startup method (see Chapter 2.2.2.) and often used in startups. Expected is that the canvas allows for a low barrier conversation to start talking about tools. IDEO's Circular Design Guide (see Figure 3.2-4) is an online library of tools related to circular economy, which for this report is considered a subset of eco-design. The goal of the website is to make enable people to bring circularity into practice. Although, this library was chosen as a conversation object for this empirical study, because of the assumption that it does not provide clear incentive for startup founders to use it.
The input of the founders of DeNoize and Trekschuit was deemed to be sufficient to answer this assumption, thus adjustments were made for the second guide.

The second guide (appendix A.3) expands the focus on the Business Model Canvas with content on circular economy strategies (Bakker, et al., 2014) with the aim of assessing if the introducing eco-design changes to the business model would bring up any barriers. The business model canvas was simplified and expressions of the circular strategies were made

(see Figure 3.2-5) to smoothen the conversation about this subject.

Analysis

For the analysis some of the principles of the grounded theory method are used. This entails the following steps:

1. Initial Coding: the data on the conversations is broken down in parts. The parts are compared to each other to see if they can fit under the same description (Strauss and Corbin, 1998), although the content should stay true to the source and not be interpreted yet (Charmaz, 2006).
2. Intermediate Coding: the codes of step 1 are grouped together.
3. Advanced Coding: this step uses the approach of hierarchical organisation (Rubin and Rubin, 2012) to categorise the groups of code, which link back to the aims of this research.

RESULTS

Based on the conversations with the five startup founders a hierarchy of insights is established. The full hierarchies can be found in appendix C.4, accompanied with paraphrases of the conversations. In total 14 groups of insights have been identified, which are categorise under the three research subjects of this study:

Criteria for an eco-design tool

The category 'criteria for an eco-design tool' contains many insights directly aligned with previous literature, and expands on it by providing point of intervention. For an eco-design tool attention should go to:

- Low time investment in both understanding the purpose of and executing the tool
- How eco-design is applicable to the startup should be made clear quickly, otherwise the startup would lose interest. Extra clarity has to be given on where in product development eco-design can be used. Some interviewees appear to think it could only be used for redesigns.
- As was a hypothesis, the level of design expertise required can't be too high. It would scare away potential users. But it also shouldn't feel as common sense, otherwise it risks to feel like it doesn't give new insights.
- If a user can flow between layers of informational depth in the tool, it can enhance their experience. For communication to others a quick overview is useful, but for internal use adapting it to current priorities is preferable.

Benefits wanted by startups

The output of a tool should be beneficial to the user. The insights of the interviews led to 6 groups of benefits for startup. Offering some of these benefits could ease the introduction of an eco-design tool into startup practice. The groups found are:

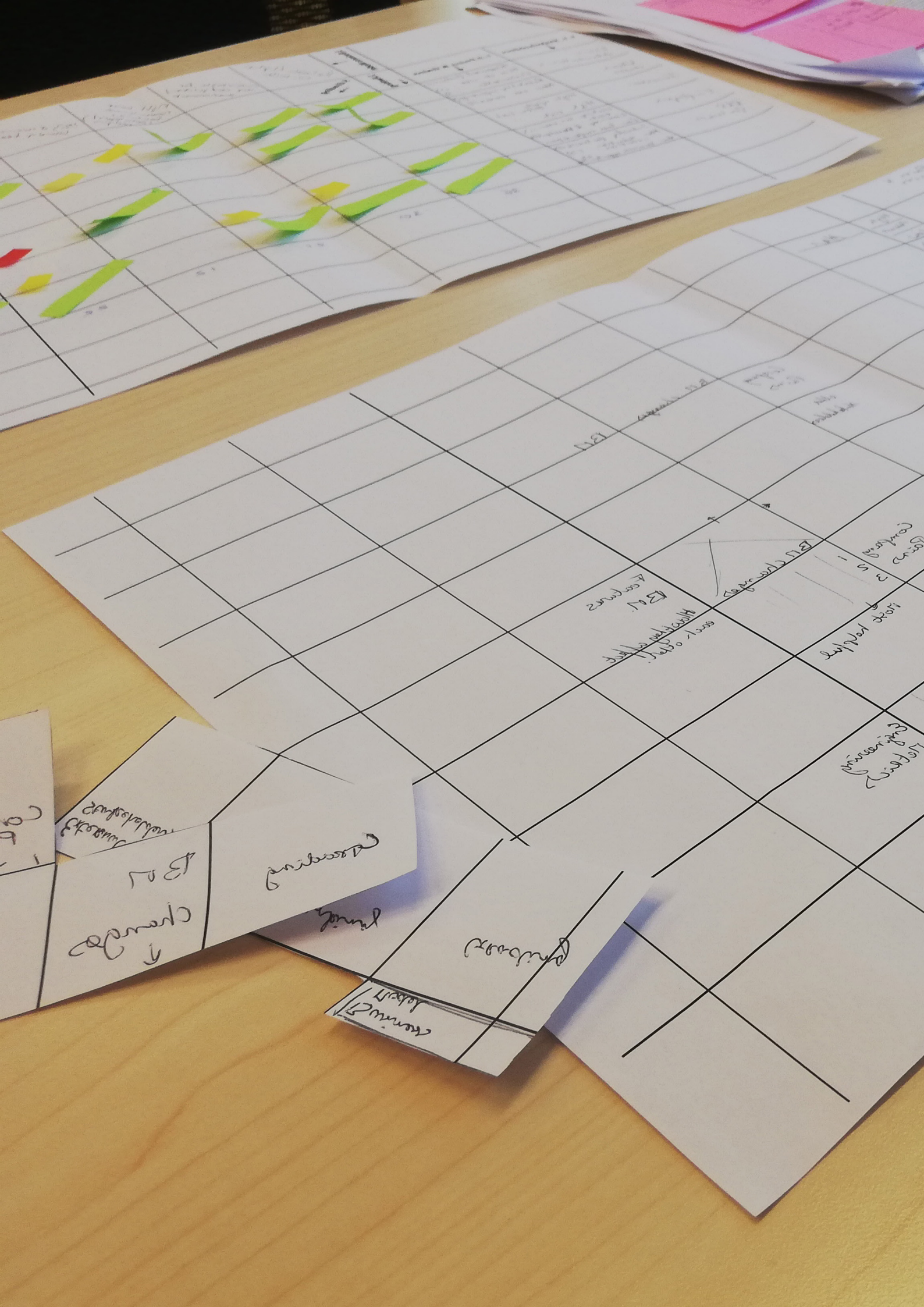
- Be applicable for investments. An opportunity might be supporting in applying for environmentally aimed grants.
- Generate income by sales. A business model works on customers being found and then being serviced. As mentioned: "If the customer doesn't value it, it is worth my time". This attitude aligns with the Lean Startup (2011): focus on the customer, everything else is waste.
- Plan for future financial growth. This means building your business in such a way that you can easily scale it when the opportunity arises, otherwise you might lose your golden chance.
- Reduce expenses. This could be obtained by making an reduction in current operations. Next to that it needs to be assessed

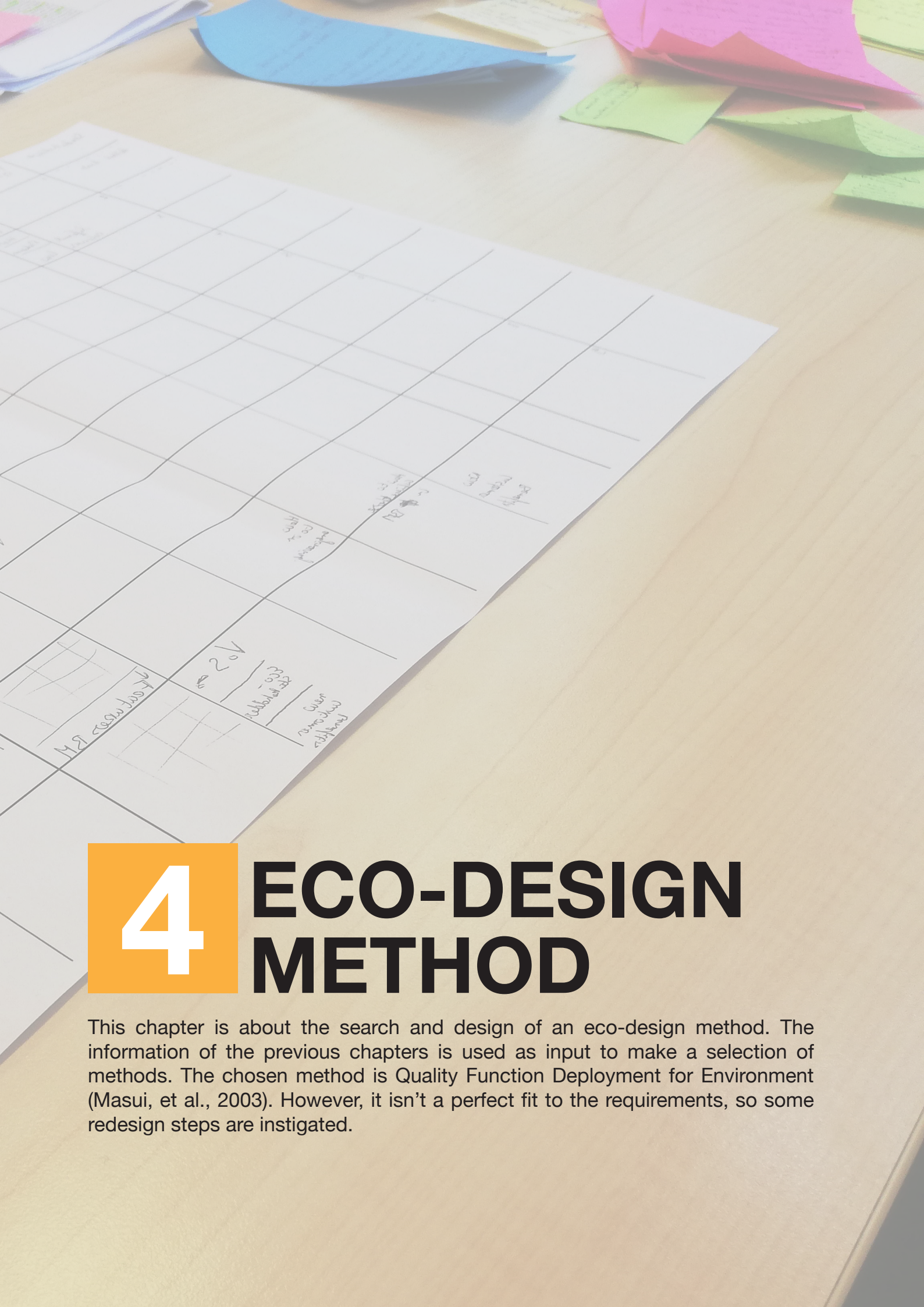
what expenses are a necessity, in particular in the manufacturing of the product. If a goal is to convince investors, a fully worked out product might not be essential, rather showing the working principle might be enough.
- Establish stakeholder connections. This mostly comes down to making multiple parties happy: a win-win. Although in some cases you might need to give up a little (e.g. freedom), to gain something else. It's a sort of balancing act.
- Solve manpower gap. Finding all the required manpower, in particular for specific skills, is a challenge. Maintaining the manpower you have as well. The later you could try to tackle with being more efficient with time use.

Processes of startups

The last category is 'processes of startups'. The use of tools is often not continuous, but by clustering some continues processes become visible. Four main processes have been identified

- Acquiring knowledge yourself. A new business is full with uncertainties, so there will be a necessity to acquire knowledge to validate the assumptions made for the business model. The customer plays the most crucial role here.
- Obtaining knowledge from other parties. This could be seen as startups using their time efficiently, instead of acquiring all data themselves, the quickly step to figures of authority to obtain it. Often these people are from within their network: startups in their hub, or mentors of the incubator. Website weren't perceived as much help.
- Design the business. The acquired knowledge needs to be put into practice. Co-creation is a popular way of doing this.
- Communicate progress. Developing a startup isn't as much about what you have done, but more how well you communicate the progress you are making. This applies to multiple facets: product and business development, set goals, and future preparations. The attention to progress communication seems essential for convincing stakeholders.





4 ECO-DESIGN METHOD

This chapter is about the search and design of an eco-design method. The information of the previous chapters is used as input to make a selection of methods. The chosen method is Quality Function Deployment for Environment (Masui, et al., 2003). However, it isn't a perfect fit to the requirements, so some redesign steps are instigated.

SELECTING THE METHOD

In 2015 there were 350 different eco-design tools identifiable (Rousseaux, et al.,2017). Nowadays that is most likely even more. It is difficult to orient on so many options, which is why a fitting paper was chosen in which academics have made preselection. The paper of choices is ‘a taxonomy of ecodesign tool for integrating environmental requirements into the product design process’ by Bovea and Pérez-Belis (2012). The reason for this choice is two-fold. This paper focuses on integration of eco-design. Many tools don’t integrate well with the processes of a company, because of which the execution of the tool is easily put to the side. The second reason is that the categories used in this paper are easily comparable to the found criteria.

This taxonomy presents 20 ecodesign tools. The first step is to narrow the scope by crossing some options away. Because of the introduction via the Lean Startup, a customer focus is a vital criteria, which brings the number to 12.

As a second step a small Haris profile (see figure 4.1-1) is made with the 12 methods. 3 criteria are used. The first two are based on difficulty level/ time requirement. The paper contains two of comparisons difficulty level/ time requirement. One focused on the manner of evaluating environmental requirements and a second on the tools themselves. These criteria are important since the literature showed that time is a critical resource for startups and that time resources are

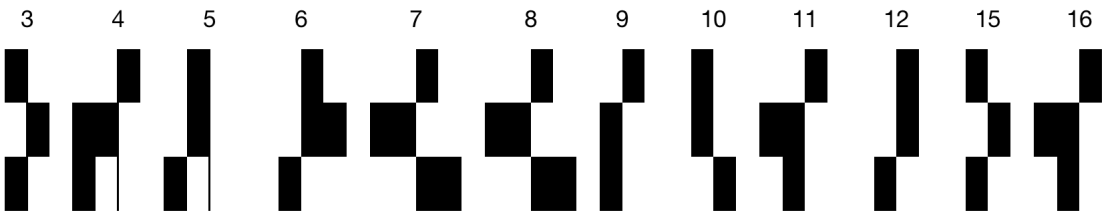


Figure 4.1-1: Haris Profile

viewed as the biggest barriers for practicing eco-design by startups (Palmer, 2000; Schaper, 2002). The third criteria is in how many different instances the method was noted to be successful in practice. As Rossi, et al., (2016) notes, there are too few methods available with applicability to real practice. According to the Haris profile, numbers 6,7, 8 and 12 are the best options to pursues (numbers correspond with the rows in Bovea and Pérez-Belis, 2012)

The last step is looking how information there is available per method. From some methods not even the original paper could be found. And for some methods the theory behind it was difficult to quickly comprehend. Since three of the top methods build on the principle of QFD, other QFD options have been looked at as well. Eventually, number 10, the quality function deployment for environment (Masui, et al., 2003) was deemed to be a good choice.

ADJUSTING THE METHOD

The chosen method to introduce eco-design in to the business model of startups is quality function deployment for environment (QFDE) (Masui, et al., 2003). However, some redesigns are required to make it fitting with the established criteria. Before going into the details of the redesign, the background of the method is explained further.

4.2.1. QFD

Quality function deployment (QFD) is the method that is used as the ground work for the QFDE.
What does this method exactly entail?

Principle

QFD has its origin in redesigning products. The focus is on increasing customer satisfaction, which is achieved by supporting companies in the translation of insights gained from customer research (or any stakeholder) to new engineering metrics for the redesign (Akao, 1990). Due to the strong division of responsibilities between departments (in this case marketing and engineering) customer insights got often warped within translation, at the moment this method was developed. QFD helps create an overview of both sides to ease communication, and thus decrease chances of mistranslation. How the customer insights are linked to engineering metrics in the overview also enables prioritisation (Wasserman, 1993). This shifts the focus from quantity, amount of customer requirements satisfied, to quality, satisfying some customer requirements as well as possible.

Benefits

The emphasis on quality with QFD can reduce cost and improve productivity due to the method decreasing the amount of defects at early stages (Akao and Mazur, 2003; Chan and Wu, 2002). Similar to the productivity, teamwork is boosted because the overview QFD provides gives clarity on the common goal of the departments (Halog, et al., 2001). Cost is also decreased as an effect of design changes decreasing with QFD (Vinodh and Rathod, 2010).

Basic Steps of the Method

The QFD consists of nine basic steps. The numbers in figure 4.2-1 correspond with these numbers.

1. Identify customer's requirements
2. Score the importance the customer gives to these requirements
3. Compare how your product compares to competitors
4. Assign a grade to how much you want to improve compared to the competition
5. Identify the engineering metrics: the technical features or functions of your product.
6. Grade how likely each engineering metric able to satisfy the customer's requirement
7. Calculate the 'sum grade'. Every engineering metric gets a grade assigned, which shows how high the priority is of including that aspect. The calculation is based on a sum between the relation grades (6), importance score (2) and improvement grade (4)
8. Grade the relation between engineering metric. This shows that some metrics might need to be developed together.
9. Set new metrics. As final output of the tool measurements are set to know when the implementation of an engineering metric has sufficiently succeeded.

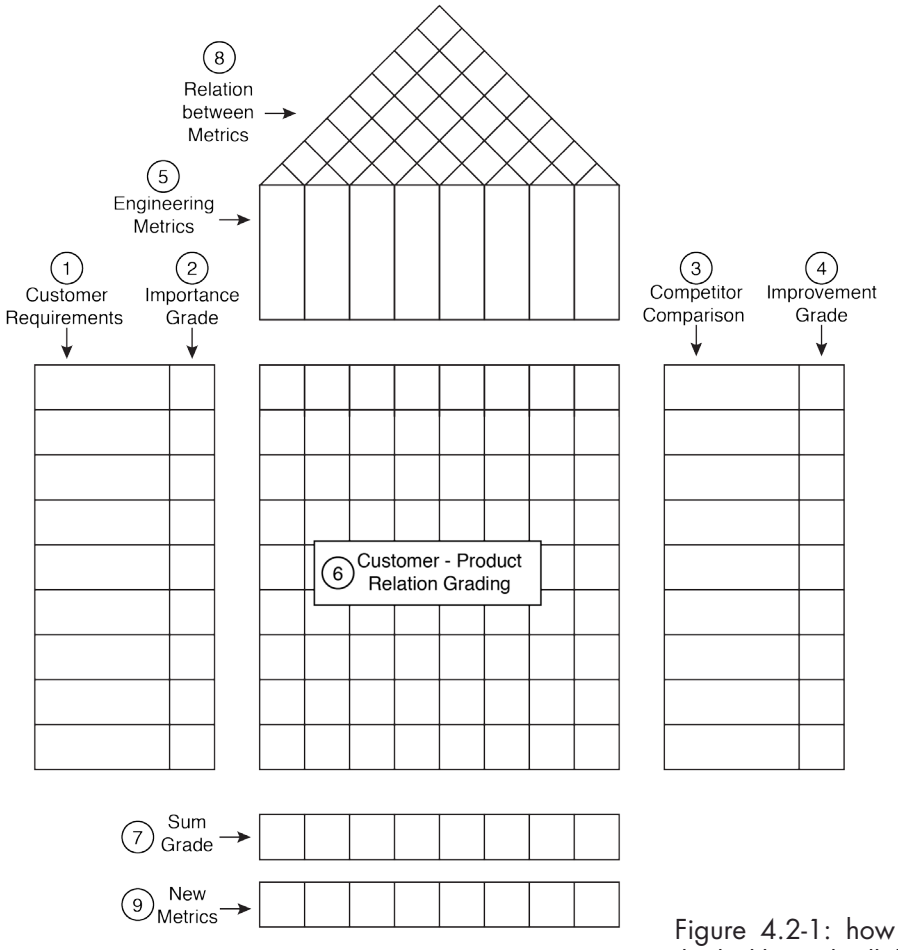


Figure 4.2-1: how the QFD matrix looks like with all the step executed.

4.2.2. QFD for Environment

QFD for Environment is a variation on the QFD, which provides two lists of suggestions for environmental criteria. The criteria's should be added as stakeholder requirements (step 1) and/ or engineering metrics (step 3). This method is applied in the early stages of product development (Masui, et al., 2003), which aligns with the findings that in these stage a successful eco-design introduction is most likely (Lindahl, 2005; Hallstedt, et al., 2013). As can be seen in figure 4.2-2, this method doesn't include the competitor comparison that the QFD has. In all other regards, the steps are treated similarly to QFD.

Principle

The premise of QFDE starts with the idea that customer requirements don't only have to relate to the user, but can be combined with other stakeholders. For eco-design this would be recyclers, the government and the environment itself. Based on these additional 'customers', two lists of environmental aspects have been generated. One list for the requirements of these stakeholders, and a list based on environmental engineering metrics. The two lists were supposed cover most environmental aspects, so the user only has to decide on what to implement, however some aspects seem a bit dated to current times. According to the creators, the lists are understandable for someone that is unfamiliar with environmental science (Masui, et al., 2003), which would align well with the finding that eco-design tools should become for non-experts (Rebitzer, et al, 2004).

After the use of QFD with these lists, the outcome shows which parts of the products are the most fit for an environmental intervention. Such an outcome relates to idea that eco-design tools should be directed more towards guiding decision making, instead of only providing assessment (Hallstedt, et al., 2013)

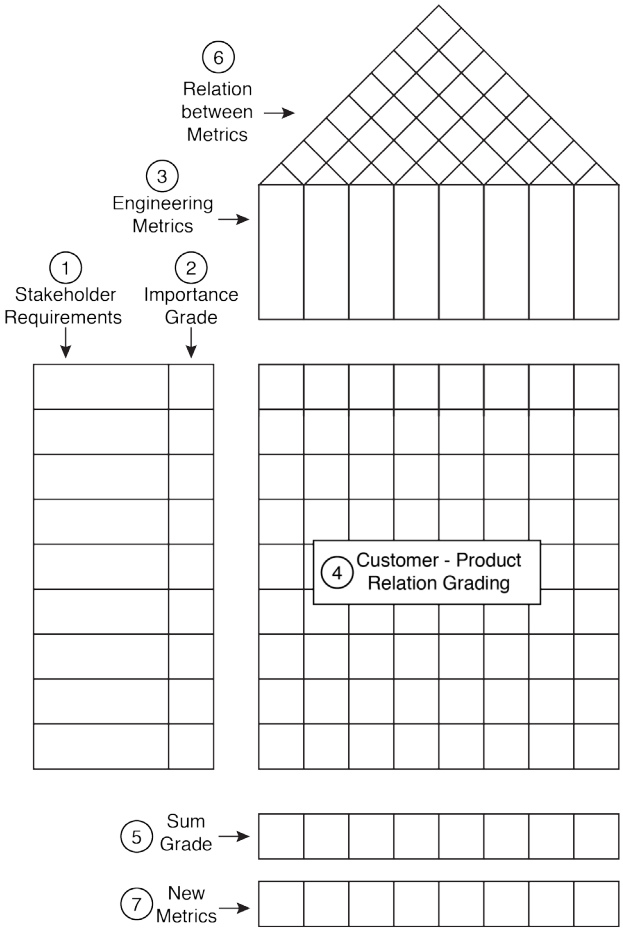


Figure 4.2-2: complete QFDE matrix.

4.2.3. Redesigns

As Mariano and Casey (2015) write, new knowledge should be reformulated to fit with prior knowledge. This means that some of the terminology used in QFDE should be altered to be fitting with a startup's knowledge. Although, most aspects are expressed in general terms. One term is changed; engineering metrics is turned into business model features, which is more relevant to the focus of startups (Bocken, et al., 2013) and also links to eco-design via the sustainable business model (Geissdoerfer, et al., 2017). However, this doesn't mean all knowledge incompatibility has been resolved. Textual reformulations are the lowest level (Mariano and Casey, 2015). Higher levels require negotiation between the actors who are sharing knowledge. This means that I need to do undertake this with startup founders, which if further discussed in chapter 5.

Another effect to look at is the escalation of commitment (Schmidt and Calantone, 2002). This effect can keep someone from accepting information that contradicts his current product development trajectory. Expected is that this can in particular affect the grades given for the 'importance grading' (step 2), because if someone is really sure about their business direction they might assume that all grade have to be the highest. Yet, step 2 can't be removed from tool, because it helps address the needs of the customer, which is an essential priority in the Lean Startup method (Ries, 2011). The option that has been opted for is to have a ranking of the stakeholder requirements next to the importance grading. This force to choose one item over another. This is called the startup ranking, which means users have to rank based on the priority the startup gives the requirement.
Figure 4.2-3 shows the final redesign QFDE.

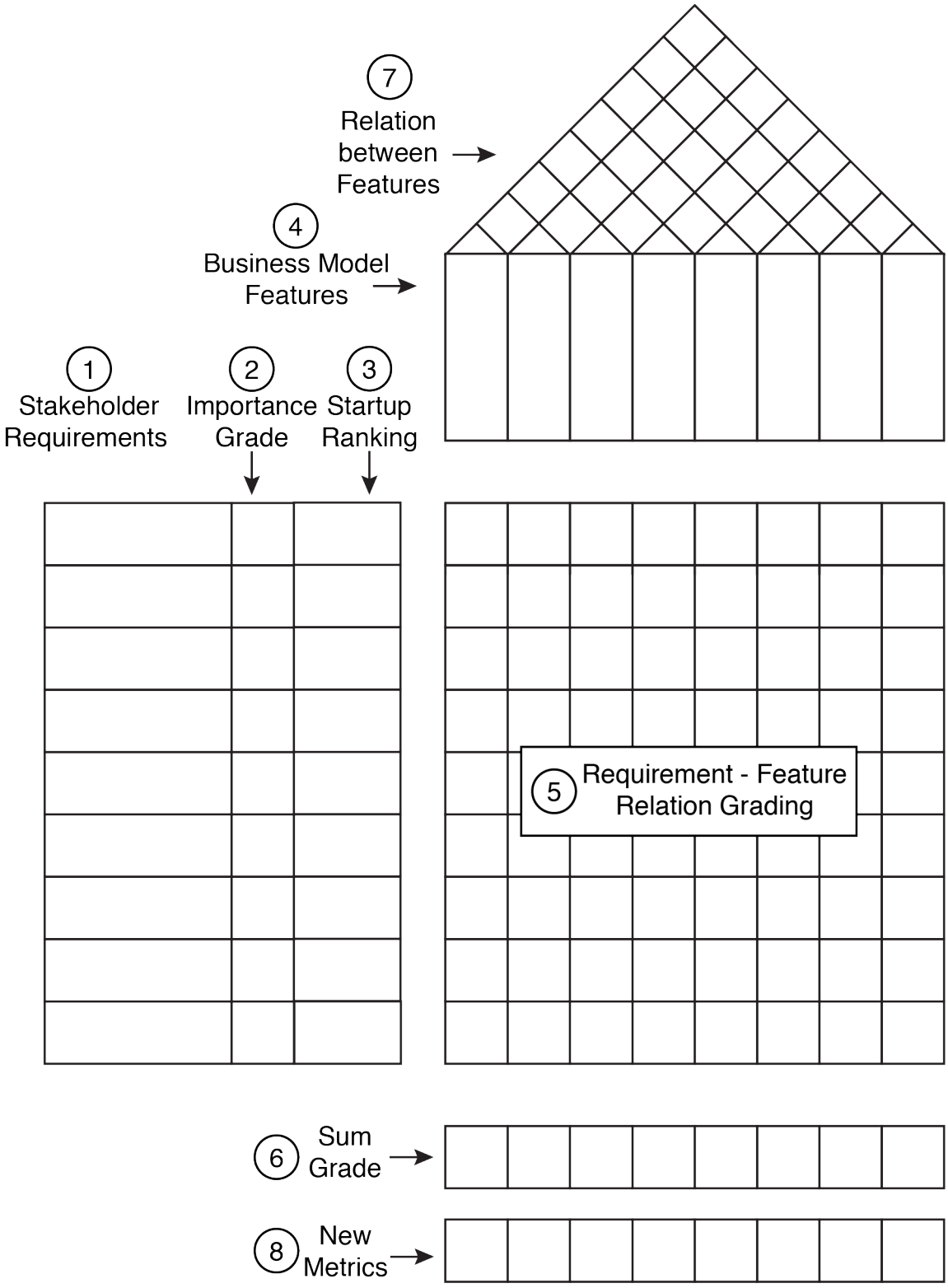
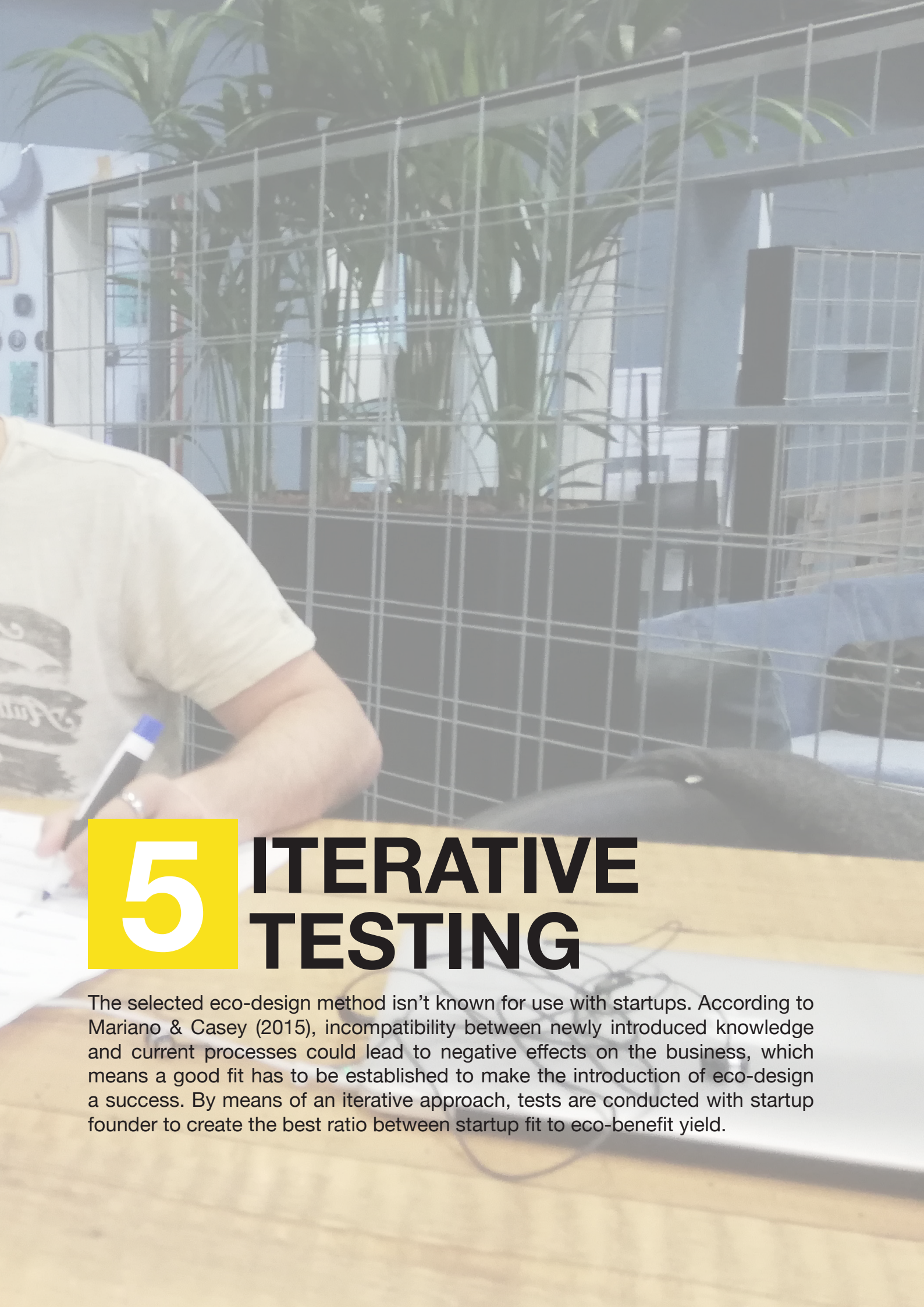


Figure 4.2-3: the redesigned QFDE matrix



5 ITERATIVE TESTING

The selected eco-design method isn't known for use with startups. According to Mariano & Casey (2015), incompatibility between newly introduced knowledge and current processes could lead to negative effects on the business, which means a good fit has to be established to make the introduction of eco-design a success. By means of an iterative approach, tests are conducted with startup founder to create the best ratio between startup fit to eco-benefit yield.

INTRODUCTION

There was no literature found on the use of Quality Function Deployment in startups. Additionally, research suggests that incompatibility between newly introduced knowledge and current processes could lead to a negative impact on a business (Mariano and Casey, 2015). Since QFD is at the core of the designed eco-tool, one aim is to assess how QFD could be used by lean startups, so no unfavourable outcomes are experience when the method is brought into startup practice.

Another aim of this study is to assess, if the eco-tool can indeed result in the introduction of eco-design into startup practice. As was found from the literature study, the benefits of eco-design should be clear for the startups to realise an acceptance of eco-design into practice. This means it is key to this research to observe if the participants indeed recognise the benefits that can be offered to them.

METHOD

For this series of tests an iterative approach is used. An iterative approach means that the outcomes of a test are used to adjust the research method of the next test. In this manner the test materials and the eco-tool that will be tested with keep evolving.

Participants

The iterative testing has been conducted with five startup founders (Appendix C.1: profiles of the founders and startups). The startups are selected with the following criteria:

- Startup does not exist for longer than 12 years (based on Shane, 2012; Ch. 2.1.1).
- Startup has a business model with high uncertainty (based on Ries, 2011; Ch. 2.1.1).
- Startup works with the Lean Startup method (method is detailed in Ch. 2.2.).
- Startup's business development is in the early design phases (Ch. 2.3.1. eco-design implementation is most likely to succeed during these phases).

Interview Guide

To get more in-depth insights on the participant's experiences with the eco-tool, a semi-structured interview guide (see Appendix C.2) has been created. Before the use of the tool start the participant is asked about his startups business and processes. This primes the participants to think about the startup holistically and not only about his current day-to-day business. As was found in literature, a holistic business approach is a step towards a sustainable business model Geissdoerfer, et al., 2017). After the participant has use the eco-tool, he is first taken along for a reflection on the tool's outcomes. For example if any results are surprising, but also if he would make adjustments to his business model based on the outcomes. Such adjustments could be the hook to introducing more eco-design methods. The reflection on the outcomes if followed by an assessment of the tool. For example, Are there any things that you liked or disliked?
Finally participants are asked about the means they would go through to get this eco-tool. These questions are asked because it can add insights about the introduction of eco-design. The means the participants are asked about refer to location the tool could be found and the cost of the tool.

ITERATION 1: SIMPLE VERSION

Both the applicability of QFD to startups and the applicability of the designed eco-tool to startup are unknown. Building up the complexity of the tool over the iterations makes it more obvious which elements cause problems for the startup founders. Because of which, a simplified version of the designed eco-tool (presented in chapter 4.2.3.) is used for this first test.
In line with the simplification, also the environmental aspects of the tool are diminished. A secondary reason for this is startup founders have previously show doubt towards the value of eco-design (Schick, et al., 2002), and we want to avoid that negatively affecting the first exploration on the applicability of QFD to startups.

5.3.1. Method

For this test the QFD matrix as presented in figure 5.3-1 has been used. The light eco-design implementation in this eco-tool version is by means of the categories for the stakeholders (#1) Based Masui, et al. (2003), the stakeholder categories are: customer, user, regulators and suppliers.

Since at first introduction the instructions to the eco-tool can seem a bit complicated, the researcher tells the instructions to the participant step by step. The instructions the researcher used can be found in appendix C.3. The participant worked with pen and post-its to allow creative freedom of the participant and flexibility in the test. The categories of stakeholders and business model features were pre-written and placed by the researcher at the start of the test.

5.3.2. Results

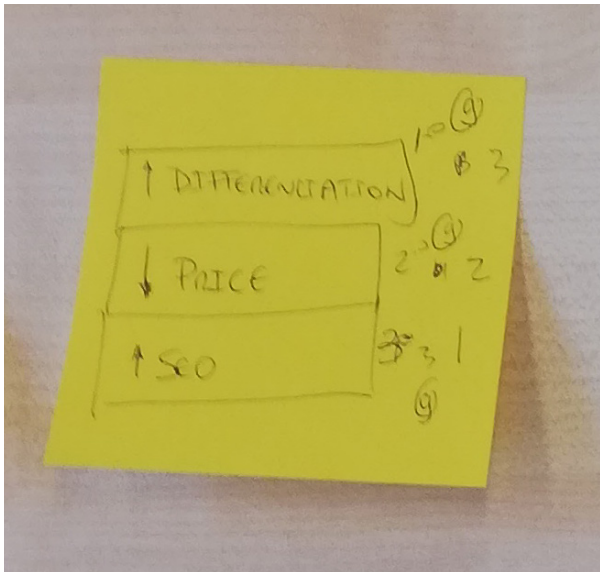
This test was executed with Kevin, founder of KM Turismo. KM Turismo focuses on online promotion of cities to increase tourism. The unique approach they have is creating 3D videos outside and inside buildings by use of drones. Kevin founded this startup in June 2016. See appendix C.1 for an extended profile.

Observations

The participant followed the grid formed by the post-its of categories of stakeholders and business model features placed by the researcher before the start of the test. Following

this grids has resulted in multiple items being written per post-it (see Figure 5.3-2, or appendix C.2 for the total outcome). The stakeholder 'supplier' was changed by the participant to 'affiliates', since he believed that would be more fitting to his business, however during scoring it turned out that the business model aspects didn't have any relation to this stakeholder.
Interesting to observe was the use of arrows to indicate in which direction a stakeholder requirement should change. In the ranking of the stakeholder requirements there was some difference between the rank given based on the stakeholder's importance and the importance the startup gives it.
In step 5 the participant ranked the business model aspects, but it was done so without a defined scale, making it unclear how aspects rank to one another. For example, is the difference between A and B as large as between B and C. This could have slanted the sum grades.

Figure 5.3-2: one of the post-its with multiple benefits of a stakeholder on it.



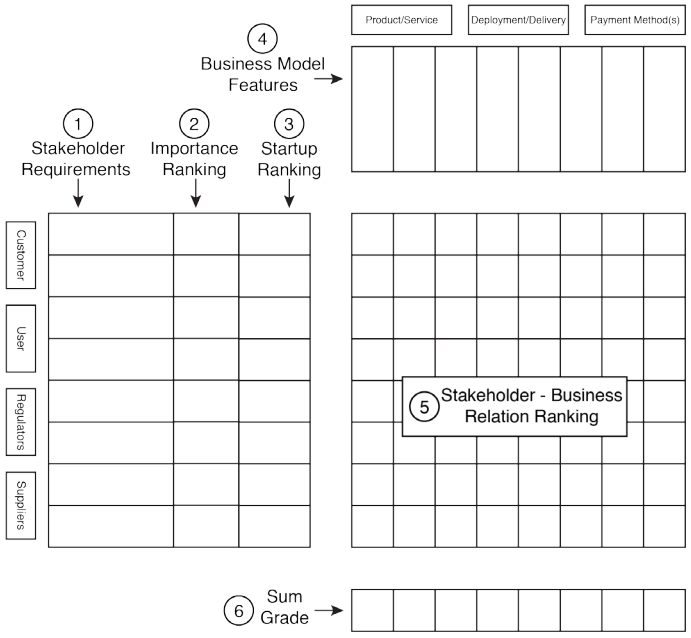


Figure 5.3-1: representation of the QFD matrix steps used in this test.

Dialogue

The sum grade of some product features was slightly surprising to the participant. He attributed this to a potential difference in mental model he has and that of the stakeholders. An example he gave is that the customer automatically expects some features, because of that the customer doesn't give much weight to it, while for the startup it is still essential to include these features. What wasn't surprising for the participant was the grade for the regulators, because according to him he only needed to have some small compliance to keep them satisfied.

While discussing the tool itself, the participant had to say that going through the tool in steps, instead of everything presented at once, was pleasant. He regarded it as being guided by questions from building

block to block. He liked doing the tool on paper with someone facilitating it, but if it has to be online, his opinion was that a tablet would be preferable, since he would like to interact with it via touch. What he was missing a bit was examples to help him understand what he needs to do.
Without being informed on it, the participant mentioned that the tool was similar to QFD, which he had learned about in his bachelor's. He also saw that the tool could offer benefit in aligning team members with the overview it provides. As for where he expected to find such a tool, a startup incubator would be most logical to him.

5.3.3. Conclusions

There was no clear indication of the participant introducing potential openings for environmental criteria with the use of this iteration of the tool. The defined stakeholder 'affiliates' came out as being unattended in the business model, which should be looked at according to the participant, but there wasn't an implication that this would be environmentally related.

The categories of post-its, as in stakeholders and business model features, resulted in the tool not being used as intended. The participant didn't have to follow the grid formed by the categories, but instead of moving the post-its, he opted for multiple notes per post-its.
This in particular affects the ranking during step 5, which had now an unclear scale, which probably affected the score outcome. Although, the participant, while familiar with QFD, didn't saw any notable surprising results from the tool.

As researcher an intervention could have been made when the participant adhered too much to the columns and rows, of the categories of stakeholders and business model aspects, however it was assumed that it might also impede the creative flow of the participant, which was deemed to be more important because the participant had to come to environmentally related criteria from himself.

Next Test

- More freedom needs to be provided to the participant in making notes for the stakeholder requirements and business model features.
- The participant should be pushed to be more extensive about their stakeholder requirements and business model features.
- The participant should be allowed more room for creativity to come up with eco-design relations.

ITERATION 2: MORE FREEDOM

This iteration was held an hour after the first, so only some small variations were introduced. The idea was to create some mirror compared to the first iteration to get a better understanding of the context of the findings. In particular this meant giving more freedom to the participant, instead of being locked by given categories.

5.4.1. Method

For this test the QFD matrix as presented in figure 5.4-1 has been used. The categories for the business model features have been removed, and an extra step in the instructions of the researches has been added to the start of the instructions during which the participant has to define the stakeholders.
All other aspects are the same as described in iteration 1.

5.4.2. Results

This test was executed with Tomas, founder of Trekschuit. This startup aims to bring back boats for service into watery city centres. Trekschuit's current focus is replacing the garbage trucks in the city centre of Delft. Tomas founded this startup in October 2018. See appendix C.1 for an extended profile.

Observations

The outcome of iteration 2 is in appendix C.10. There are 3 stakeholder requirements listed per defined stakeholder. This isn't a coincidence, but based on a suggestion by the researcher given to keep the duration of the test within the available time. What can be observed is that some of the requirements overlap, so in actuality there are less requirements that need to be satisfied. Since he graded these

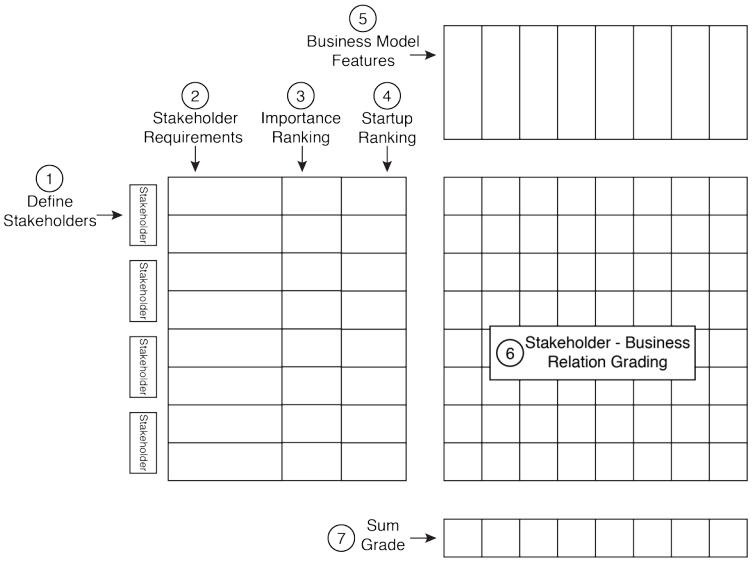


Figure 5.4-1: representation of the QFD matrix steps used in this test.

overlapping requirements the same in step 6, these were taken as one for the sum grade. As for the phrasing of the stakeholder requirements some interesting variation can be viewed. Some are concrete with a scale. For example, “minder belasting op de wegen” (Less taxing for the roads), or “minder vuil op straat” (Less garbage on the streets). Other requirements just exist out of one word, like “afvalscheiding” (Waste separation).
Noticeable in the phrasing of the business model features is that they are phrased as final and not much as features that is in development, for example “autonoom varen” (autonomous sailing). The features do all contribute to a greater business model system instead of a singular product focus. In step 6 one feature didn’t get any grades and some barely any.
At step 4 ‘startup ranking’ the participant didn’t have any other ranking than written in step 3.

Dialogue

Some dispute came up at step 4 ‘startup ranking’. The participant was convinced that the ranking of the startup wouldn’t be different from the ‘importance ranking’. After some probing he presented a vision, which wasn’t a one-on-one copy of the customer requirements, meaning the rankings could be different, but he decided he would stick to the earlier given ranking.
His response on the sum grades was that the outcomes were quite understandable and that it nicely framed what was important. The participant said this tool is a good way to set priorities, which he also saw returning in some business model features not being too relevant at the moment, and that in this way future validations could be planned.
On the use of the tool, the participant said he liked that the questions are coming to him, one by one.

As a response on the question where he expected to find such a tool, he said that he expected some authority, for example a startup coach, to introduce it to him. He continued by mentioning that the likelihood of use of the tool in his startup would increase if it could be integrated with other services like Microsoft Office or Gmail. He compared it to the programme Trello, which he had used on some occasions, which also worked as an add-on planning tool. In particular what would be handy is if all members of the startup team can have access

to it, so it enhances communication. In their startup they for example use Microsoft Project to create a canvas overview.
Building on the idea of communication, it is mentioned that a tool like presented in this test could take other people (i.e. external stakeholders) along in the story of the startup and its iterations.
As a last remark, Tomas asks if he could get the source for the tool, because he actually would like to try to implement it in his startup. He follows this up by saying, that he might not be the one doing it, but that it might be a good assignment for their newest employee.

5.4.3. Conclusions

Some features were shown to have little connection to the stakeholder requirements, showing that the startup could reduce some of its efforts. If followed through on this, it could potentially benefit the startup in reduction of necessary manpower and the environment in unnecessary products not coming to existence.

The insight gained on the dispute around 'startup ranking' and how it differs from the 'importance ranking' could be concluded as three different things being confused: the importance the customer gives to it, the importance given to it in the value proposition of the startup, and the importance it has in the startup's vision. Looking at the data, it seems like the participant focused on its value proposition, which won't differ much from the customer requirements because only a few were listed. Most likely, with a more extensive version of the tool this wouldn't occur, although the instructions could also provide more clarity on the differences.

Next Test

- remove startup ranking
- focus more on the value proposition aspects of the business model
- have the participant interpret the instructions for himself.
- put eco-design more obviously in the tool

Figure 5.4-2: participant making a grid of post-its.

ITERATION 3: DO-IT-YOURSELF

The main goal of this test was exploring how the participant would handle a more straightforward use of environmental criteria. In the previous tests the trial was to not explicitly use environmental criteria. There was some slight hints towards it, but a stronger effect is need to build a good case.
The secondary goal is to see if the participant would be able to execute the tool with written instructions, contrary to provided by the researcher as in iteration 1 and 2.

5.5.1. Method

For this test an instruction guide for the participant has been made (see Appendix C.4).
Most important is that it it the user is asked to define the environmental cares of the stakeholders and add those to the other stakeholder requirements. The guide gives some suggestions on what such cares could be

Some alterations have been made to the tool itself. Stakeholder requirements has been changed to 'pains & gains', which is based on the value proposition canvas (Osterwalder, et al., 2014) as a relation the finding about the value proposition in the last test.

To minimise the duration of the test the participant was asked to only do two stakeholders as seen on the left side of the tool (figure 5.5-1).

DeNoize

5.5.2. Results

This test was executed with Aman, founder of DeNoize. DeNoize focuses on noise-cancelling technology for windows. For this test we have focused on the use of this technology for yachts.
Aman founded this startup in March 2018. See appendix C.1 for an extended profile.

Observations

Appendix C.11 shows the QFD matrix created in iteration 3. The participant could come up with more pains than gains. Additionally all pains rank higher with 'importance ranking' than the gains. The environmental cares are ranked even below that. Interestingly,

the environmental cares are similarly phrased as the stakeholder gains. This phrasing is recognised by the use of scale, for example “more comfort”.
At step 4, the features are written like goals to be achieved for the product.
A sum score was given per stakeholder. This decision is based on the notion that the ‘user’ didn’t have any environmental cares. The result is that the rank, based on the sum score, of 2 of the 3 features switches with the stakeholder.
An unintended insight of this test is due to the instruction to the user to write ’N’ when there is no connection. The insight is that now will all cells filled there is less of a quick overview of where the relations are.

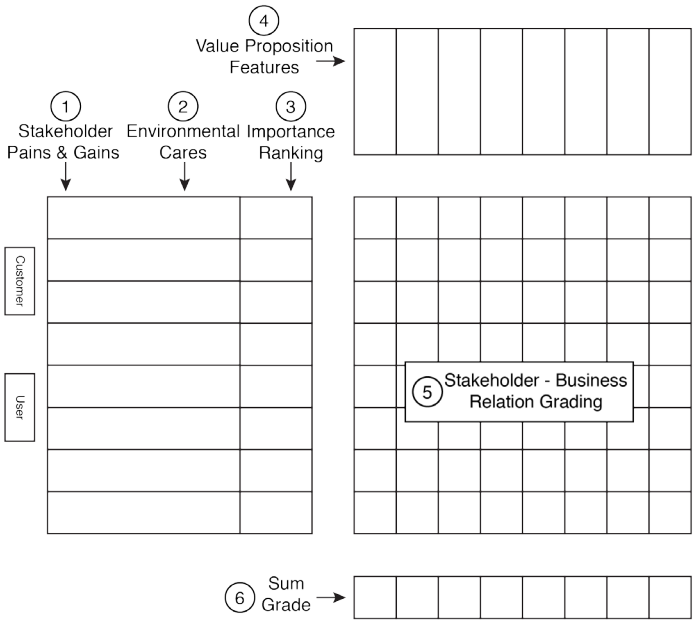


Figure 5.5-1: representation of the QFD matrix steps used in this test.

Dialogue

The outcome was perceived as slightly surprising due to the order of priority switching between stakeholder. In particular because the tool suggested this could be due to the environmental cares. However, he questioned what the exact benefit for him was to take this eco step. When asked on what he based that the user doesn’t have any environmental cares, he said that it was information provided by the customer.
The participant was additionally asked to judge which environmental engineering metrics (Masui, et al., 2003) would apply and be useful for the startup. 9 out of 15 were relevant (see figure 5.5-2). As explanation of why these were selected the answers were mostly related to it benefiting the customer or user. Another remark was that such a list is a good start, but that he would expect more categorisation.

What the participant liked about the tool was the use of pains and gains. It was a helpful way of reasoning for him. It also reminded of tools taught at Yes!Delft incubator he is part of, such as value proposition canvas. Because of this he also would rather keep using this tool on paper and would expect it as workshop at an incubator. He added that paper is more open for creativity. A digital tool would be more useful after a first use to iteratively keep track of the priorities. After some time of free use he might actually pay for such an online tool.
The participant was also positive about the learning curve being small. It was a not so difficult way to create an in-depth overview of priorities. Next

to that he saw potential benefit of the tool in the shape of collaboration with his team members. It could help keep everyone up-to-date but also allow for people giving different opinions about priorities. He even envisioned going directly to the customers to let them do the 'importance ranking', instead of doing surveys.

Lastly, he had some improvements suggestions for the presentation of the outcome. The participant would like to see it presented more visually. In a quick view he would like to be able to tell 'how far am I from my goal?' and 'how far am I from the customer fulfilment?'.

5.5.3. Conclusions

The goal was to include environmental criteria more explicitly in the tool and it showed to have some effect with regard to the outcome of the tool. An interesting observation was how environmental cares are more phrased as gains than pains to be resolved. However, a clear lack in this current iteration is how it benefits the startup, which was voiced by the participant. Although, it could be seen as a contradiction with his understanding how most of the criteria would benefit the customer or user. Another area the tool is lacking is what the user should do after the interesting environmental criteria are identified.

A point of attention might also be the sources of the stakeholder requirements. No environmental cares were included for the user, since the customer said they didn't have any. It could be a useful suggestion to users of the tool to validate if the requirements they are or aren't using.

The secondary goal of this test is to see if the participant could execute the tool on its own. The results looks promising. Some phrasing could use improvement, but the general tool structure was accurately followed. As remarked by him, categorisation could be provided regarding the environmental criteria.

Next Test

- present clearer benefit to the startup for implementing eco-design
- move towards a full template

(2) *Environmental EM*:

- Weight: the weight of the product.
- Volume: the volume of the product.
- Number of parts: the number of parts in the product.
- Number of types of materials: the number of types of materials in the product.
- Likelihood of getting dirty: the speed of change of the exterior color by the effect of dirt.
- Hardness: the hardness of the parts in the product.
- Physical lifetime: the physical lifetime of the product.
- Amount of energy consumption: the amount of energy consumption along with all the life-cycle stages.
- Rate of recycled material: the rate of recycled materials in the product.
- Noise, vibration, electromagnetic wave: the volumes of the noise, vibration, electromagnetic wave given out during the use of the product.
- Mass of air pollutant: the mass of emission of air pollution substances along with all the life-cycle stages.
- Mass of water pollutant: the mass of emission of water pollution substances along with all the life-cycle stages.
- Mass of soil pollutant: the mass of emission of soil pollution substances along with all the life-cycle stages.
- Biodegradability: biodegradability of the materials of the parts to be landfilled.
- Toxicity of materials: toxicity of the materials of the product.

Figure 5.5-2: list of environemtal engineering metrics (Masui, et al., 2003)

ITERATION 4: THE TEMPLATE

The literature study has shown that there needs to be a benefit for the company in implementing environmental criteria. Iteration 3 again confirmed this when the participant mentioned he did not understanding why he had to take the environmental steps in the tool. This iteration provides a template on which the participant can see how implemented eco-criteria relate to his business and could benefit him.

5.6.1. Method

Most of the tool is similar as the one used in iteration 3. The eco-design intervention has been moved from 'stakeholder pains and gains' to 'business model features' (see figure 5.6-1). For this the instruction guide also has been updated (see Appendix C.5). A list, roughly based on Stevels (2001) and Masui, et al. (2003), with links of potential company benefits to business model changes, is provided as support for step 5.

Next to that some aesthetic changes have been made. This is the first iteration with a printed grid. The grid has many cells to not limit the participant (see Appendix C.6). For the grading colours are used with the intent of giving a better visual overview of the outcome.

Drones for Work

5.6.2. Results

This test was executed with Robert, founder of Drones at Work. This startup focuses on creating flight controllers for drones, which they sell to drone manufacturers. Drones for Work aims to produce the most reliable and stable control system on the market with their aerospace knowledge. Robert founded this startup in February 2018. See appendix C.1 for an extended profile.

Observations

Appendix C.12 shows the QFD matrix created in iteration 4. The stakeholders were put in cells directly below each other. Following from this the pains

and gains were also put per three in a cell. The ranking column wasn't used as well. It was attempted to adjust the test with smaller grading stickers, fitting to the size the pains and gains were written, but the participant still just graded per cell.
The participant took relatively long about grading in step 6, compared to the tests before.
The newly introduced changes to the business model in step 5 scored lower than the startup's business model. The last one in the list has a promising score, but upon discussion it seemed that the participant envisioned something else than eco-design with it.
A grading of the stakeholders was also made to potentially get another angle on the new introduced concept. It showed that the most important stakeholders (Drone manufacturer (i.e. customer) and R&D partner) score high with the added business model changes.

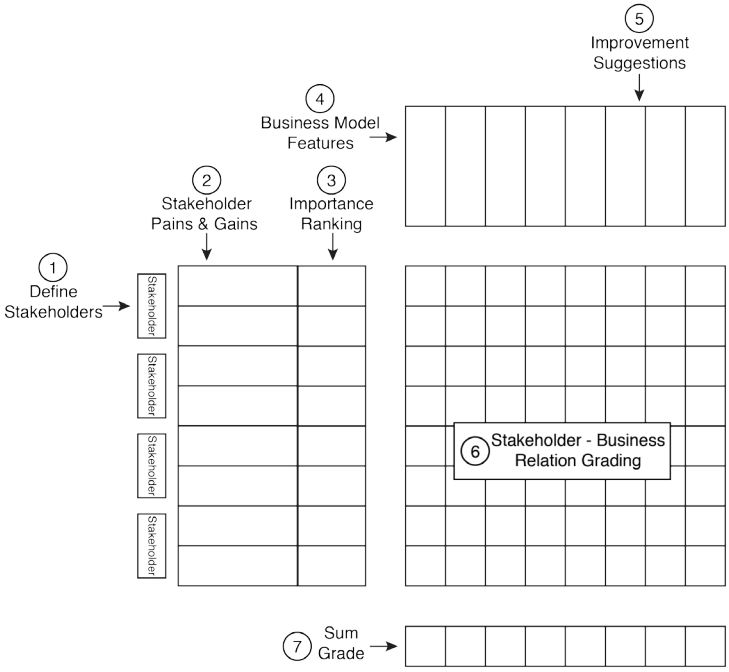


Figure 5.6-1: representation of the QFD matrix steps used in this test.

Dialogue

The participant dwelled a lot from the instructions provided. During the test he also acknowledged that he wasn't reading the instructions correctly. While reviewing the tool, he remarked that he could have easily graded per pain or gain, since there was enough space available. Next to that he remarked that he only wrote down gains and no pains, since there wasn't enough space for it.
On the topic of pains and gains he mentioned he was familiar with it because of his time at Yes!Delft incubator.
In reflecting on the final outcomes, the participant said that most of it wasn't really surprising, although that his interest was sparked to look at new directions again.
As feedback on the tool he said that the suggested business model changes were more applicable to physical products, and while they have a small physical part, it isn't the main focus of the business. In such a sense the suggestion were not too relevant for his startup.
When discussing the potential of the tool, he was quite excited about the potential, and asked to get the final design of tool when it finished.

Due to time constrains, topic 5 "getting the tool" on the interview guide wasn't discussed.

5.6.3. Conclusions

The scores of the business model changes, thus eco-design interventions, being lower could be attributed to two factors. Firstly, if the tool would have been correctly executed the spread of grading could have given a better overview of the differences. Secondly, maybe the changes shouldn't be compared to the current business model. It is logical that most priority lies on the current, and thus would score higher.

The goal of letting the startup create benefits for itself via the tool also wasn't achieved. An important factor is that the suggested changes didn't fit with the business model of the company.

Next Test

- template and instructions should be more concrete in actions to take
- eco-design should be brought into relation the business model features

Figure 5.6-2: participant work on templates.

ITERATION 5: MULTI-CANVAS

In iteration 4 the tool wasn't used as intended, although an observation that still could be made is that the business model changes (which were based on eco-design strategies) scored low on priority compared to the startup's business model. Since the priority is low, it would mean the chance of the startup implementing it is also low. This iteration introduces extra steps to see how business model changes would affect the current business model. This means no side by side comparison of priority. The new iteration of the tool should help the user understand the possible benefits to be gained via business model changes, and how that would affect the current business

5.7.1. Method

The template (Appendix C.8.) and instructions (Appendix C.7) have been updated for this iteration, so there is less change of incorrect use. For this purpose the previous 'importance ranking' (score relative to others) has been changed to 'importance grading' (score per unit), a variant not uncommon for QFD (e.g. Masui, et al., 2003). Additionally, there are two new grading grids. The participant starts off with defining company pains and grading this to potential business model changes (Figure 5.7-1). The company pains have been limited to 3 for the purpose of the test. A list like in iteration 4 is provided to help translate pains to changes. The test ends with the second additional grid, of which the grading shows which changes have a high potential for adoption in the current business model while giving the company some pain relievers. The final grade at step 12 is calculated by multiplication of the grade at step 4 with the relation grading the participant gives in step 11.

ENVISION

5.7.2. Results

This test was executed with Karthik, founder of Envision. Envision aims at making the life of the visually impaired easier. They try to achieve this by using the input of mobile devices together

with AI to translate the environment to the user. Karthik founded this startup in October 2017. See appendix C.1 for an extended profile.

Observations

Appendix C.12 shows the QFD matrix created in iteration 5. The company pains defined in step 1 aren't much product related. As a result, the business model changes are based more on the ideas of the participant rather than the suggestions provided on the instruction sheet.
For the importance grading few "low"'s are selected. For the relation grading between stakeholder and business a lot of "high" is used.
The final outcome, step 12, has "decrease product features" as highest scoring, which is a eco-design related concept.
The participant follows the structure of the template well. With the update instructions the use of scale in stakeholder pains and gains also has improved.

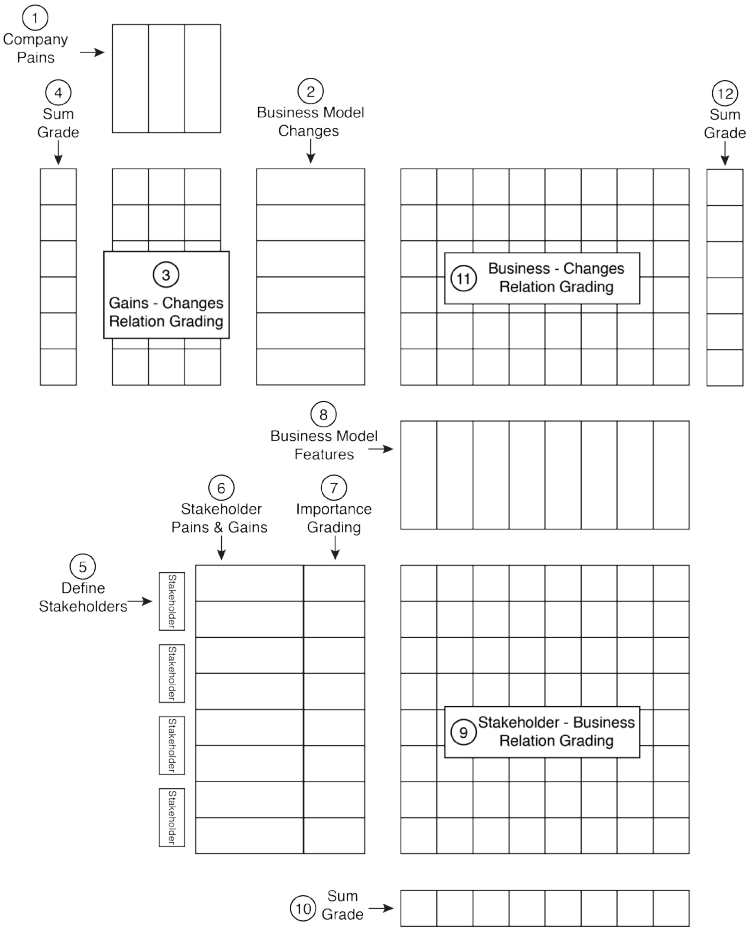


Figure 5.7-1: representation of the QFD matrix steps used in this test.

Dialogue

During the use of the tool the participant had some questions. Starting with identifying company pains he questioned if he could also add something about hiring. Suggested was if he wants to do this, it is advised to be specific what sort of person you want to hire. He also wondered how specific the stakeholder pains and gains should. Later on remarked that more examples next to the instructions would be helpful to guide him along.

On the topic of pains and gains he also had to say that he wasn't sure about the context. The example he gave is that these terms were present in his studies and at the incubator he was part of, but at both the terms were had a different implication.
Speaking about the outcome of the tool, he thought the correlation it showed was interesting. In particular he remarked how two first unrelated axes (i.e. changes and business model) were brought together to create new insights, and that this action flow

avoids the creation of some biases. It showed him some new ways of approach for the future. Although, to make it even more helpful for him the suggestions for the changes given with step 2 should move away from the hardware focus.

Due to time constrains, topic 5 “getting the tool” on the interview guide wasn’t discussed.

5.7.3. Conclusions

The approach of linking company pains to the business model by means of a shared relation via potential business model changes seems to provide a good method of actually inducing change in a company. There are some minor hints (i.e. “decrease product features” scored high) that these changes could be beneficial to the environment as well, however it should be more apparent to state this as an actual conclusion. In the case of this startup, the environmental relation might also not have been as big due to suggestions based on hardware not being to relevant for resolving the company’s pains.

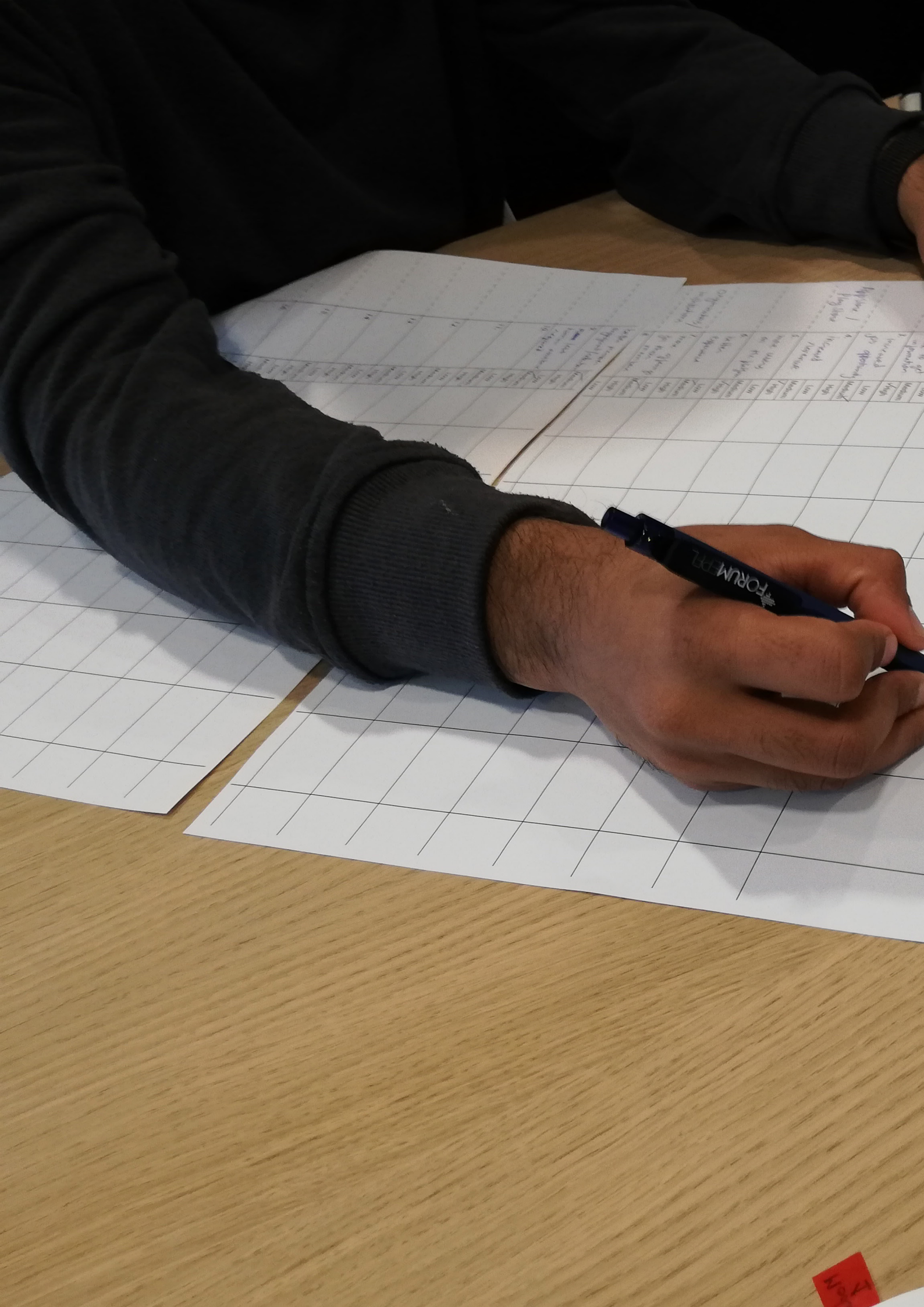
This iteration of the tool has much better results when it comes to the participant executing it. As suggested some examples could be given to make it even better.

CONCLUSIONS

During these iterations with startups, there was no solid evidence of environmental criteria being added to startup business. There were some hints to eco-design principles, that with further improvement could give beneficial results for the environment. For example, the QFD intrinsically gives insight in the necessity of features, which allows some features to be cut-out before resources have been invested on them. Also, by means of the tool the participants seemed to open up to making changes in their business model.

Furthermore, participants saw benefits in the use of the tool itself. Three of them mentioned what it could offer in terms of collaboration. Team members could align their priorities to plan future validations. The overview the tool gives can keep everyone up-to-date, even take external stakeholders along with the iterations. Participants were also fond of the step by step approach. As one noted, such an approach avoids biases, in particular in scoring and grading.

While not all participants properly used the tool, overall the reactions were positive. The instructions were easy to understand, though inclusion of examples would be helpful. By three participants the tool was compared to other tools with a similar low learning curve, such as value proposition canvas and business model canvas. Another parallel between the tools is the use of a paper template. Participants voiced their preference to keep the tool on paper, at least for the first phases. However, during the tests calculations were executed by the researcher. This gives three options: execution of the tool should be facilitated by someone (like by some participants), instructions should be provide on how to do the calculations, the user should fill in his grading in a digital tool after the use of paper. Going towards a digital version would offer additional benefits, especially the ease of using the tool iteratively.


FORUM PRL

6 FINAL DESIGN

At the end of the iterative testing there were still some imperfections in the design left. Next to that the user wasn't give the possibility of executing the tool singlehandedly. This chapter makes the final iteration of the design for this project. After detailing, the design is evaluated based on the criteria established from the literature and user research. This chapter closes with some notes on how future development of the design could look like.

6.1 Design

DETAILING OF DESIGN

During the tests with the participants I was like a guide making sure they didn't move too far from the trail. The next phase is to take a step back and let the tool speak for itself. It won't be referred to anymore as a version of QFD. It is called the Improvement Identifier Canvas. This is a canvas existing out of 3 sheets, a slide deck with instructions and a 'Change Diagram. These three items will be further explained.

6.1.1. Change Diagram

The change diagram is like a database of eco-design actions and related benefits. The diagram exists out of three parts: benefits, changes, and methods of realisation. The benefits exist out of company benefits and customer benefits, so it complies with the Lean Startup focus. The changes are actions related to the business model, which if realised, could generate the benefits. When a change has been chosen, one goes to the 'methods of realisation' to find ways to put the changes in effect.

The main source for the Change Diagram is Stevels (2002), because of which most changes and method are directly related to eco-design. One of the five ways of profiting from eco-design that Stevels (2002) proposed is taken out. This way is 'quality levels'. It has been taken out, since in relation with the benefits wanted by startups found in the user research, this was the only way that has no connection to what the startup founders want.

To further group the benefits and changes, notes have been taken from business model elements and the fundamental resources (knowledge, man-power, capital) established in the startup literature. Such a relation to concepts that are known by the startups should lead to a higher acceptance of the solution (Mariano and Casey, 2015).

As can be seen in the Change Diagram, not all cells are filled because, there are some gaps of knowledge. Also, eventually the methods of realisation should link to sources on which the instructions of the methods can be found, however there was no time to realise that yet.

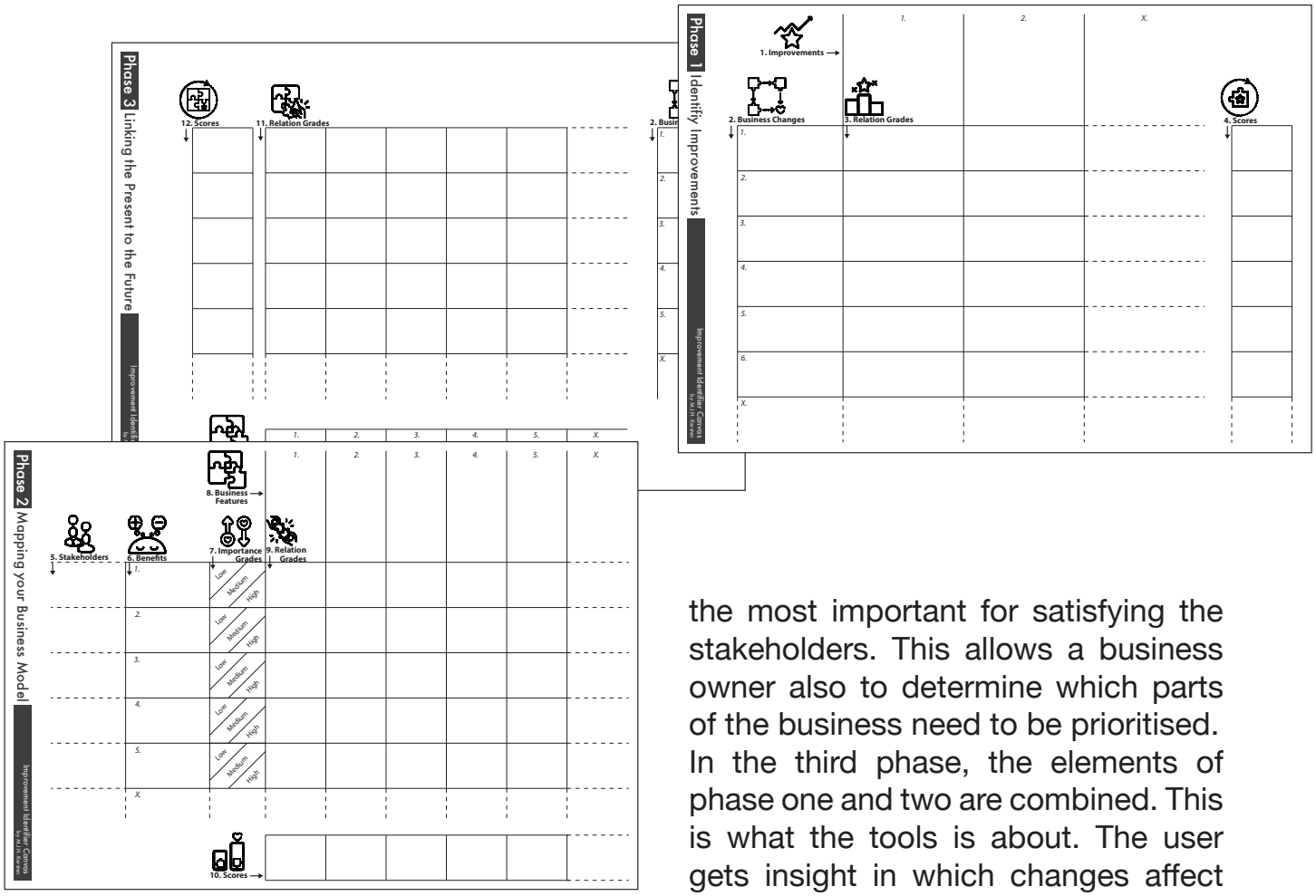


Figure 6.1-1: how the 3 sheets are placed with each other.

6.1.2. Canvas

There are 3 sheets that together form the whole canvas (Figure 6.1-1). Each sheet is a different phase. The first phase lets the user explore the link between possible improvements for the business and what sort of changes could realise those improvements. Someone might choose a change to fulfil one improvement, but might discover it covers multiple.
Phase 2 is about the current business model of the startup. This phase is fairly similar to the QFD this tool is based on. It focuses on identifying which business model features are the most important for satisfying the stakeholders. This allows a business owner also to determine which parts of the business need to be prioritised.
In the third phase, the elements of phase one and two are combined. This is what the tools is about. The user gets insight in which changes affect which parts of the business, and what there is to gain from implementing this change. Phase 2, with the current business, is also place after phase 1 so the user keeps an open mind to how the changes can be linked to the business. If it was the other way around, a user would quickly start doing the steps of phase 3 in their head, when deciding on the changes, which would bias the results.

The sheets are designed for A3 format paper, yet still the amount of cells that can be displayed is limited, so the dotted lines towards the ends of the canvas are to suggest the possibility to extend the range of the grid. For users there is also an extra sheet available which is only a grid of cells.

6.1.3. Slide Deck

The slide deck is the instruction manual of the tool. Per slide a step is presented, since the participants of the tests favoured a small step by step approach. The slide link back to the canvas by means of the numbering and icons. Each step also comes with an example to help the user along.
Furthermore, the tool will require some basic mathematics skills, since some calculations need to be done. For the iterative tests, all calculations were done by the researcher, but now this is detailed in the slide deck.
One calculation of note, is the final sum at step 12. Some variations were tried, but the eventual decision is to add the grades over the X-axis. The reason for this lies more in what it is not. For other variations of calculation that were trialed, the focus was centred too much on business model features at the completion of the tool. This could result in someone applying a change to only a single feature. However, a good implementation of eco-design needs a holistic approach to the business model (Geissdoerfer, et al., 2017).

6.1.4. Improvement Identifier

The real strength of the Improvement Identifier Canvas lies in how the canvas and diagram work together. Together the materials work on the principle of opportunity identification (Herrmann, et al., 2008; Volkmann, et al., 2009; Lourenço, et al, 2012). With the Change Diagram you can see the benefits, but it becomes a true opportunity if you learned how it applies to your specific situation (Schick, et al, 2002), which you do with the canvas by means of assessing the relation between the changes and your business model. If you come to the conclusion of the opportunity yourself, you are also more focused on the benefits instead of what it will cost. Cost of resources is often stated a large barrier to executing eco-design (Schick, et al., 2002; Rossi, et al., 2016), but this method sort of circumvents that issue by placing the focus on another area.

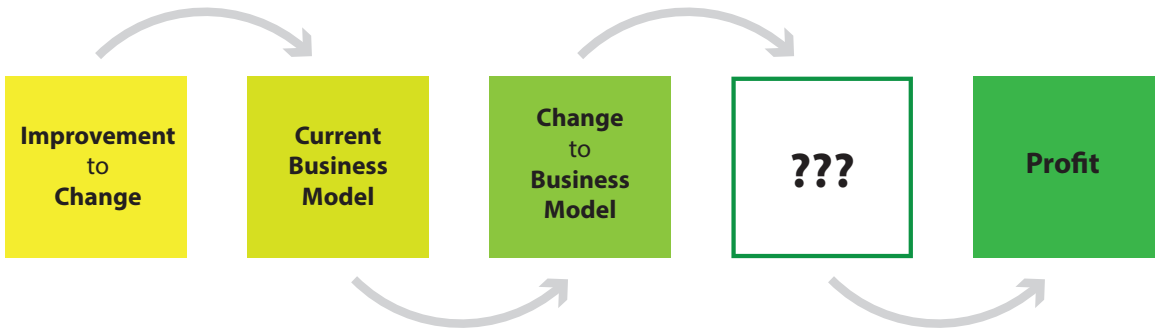


Figure 6.1-2: Order of steps of the Improvement Identifier Canvas

EVALUATION OF DESIGN

Based on literature and user insights the Improvement Identifier Canvas is evaluated. A look is taken at where there are limitations to the tool identifiable, and can this be improved in the future. Furthermore, a reflection is held on some key criteria that haven't addressed somewhere else. In some occasions a criteria might be perfectly covered by the tool, in other cases it shows that there is still improvement needed in the future.

6.2.1. Change Diagram

There are some limits to the diagram. There is a large assumption that the connections Stevels (2002) concluded are correct. If not it, there could be some bad outcomes. These can range from not getting the wanted benefit from a change, to actually creating a worse environmental impact. It would mean users should keep a critical mind at all times, however often people don't tend to do this. Maurya (2010) observed this behaviour also for lean startups. Especially when it is about an area of knowledge people are unfamiliar with, which could be startups about eco-design.
Based on the literature of knowledge acceptance (Carlile, 2004) two options are suggested to resolve this issue in the future. The origins of the knowledge should be transparent to the users and the creation process of the method should be transparent to the users. Having access to this kind of knowledge would enable more critical thought.

6.2.2. Criteria from Literature

Here some important criteria are discussed that haven't been mentioned yet in a relation to the Improvement Identifier Canvas.

Eco-design

There are two criteria related to eco-design need to be addressed:

- Ideally the method allows for short and long-term approaches,
- Take a sustainable business model approach,

The criteria are also related to each other, since a sustainable business model require a long-term approach (Geissdoerfer, et al., 2017). The short-term approach is a necessity to keep making use of the Lean Startup method. Another aspect of the sustainable business model is offering benefits to multi-stakeholders (Geissdoerfer, et al., 2017), the Improvement Identifier does provide this possibility. The focus is thus the

long-term approach, and how does the Improvement Identifier facilitate this To be short, at the moment it doesn't facilitate this possibility, which means that startups can't become fully sustainable businesses with the Improvement Identifier. Although, it is also not the goal of this research, to have that level of eco-design change in startups.

Motivation

For continues use of the tool, there should be a continuous motivation (Ryan & Deci, 2000). With the Lean Startup focus the motivation of startups should be driven by the goal to satisfy the customer. This would be categorised as an extrinsic motivation. However, the strength of extrinsic motivation diminishing over time. If the decrease in motivation strength is not prevented, it will lead to a point that the Improvement Identifier won't be used anymore. Although, with a tool like the Change Diagram there are many options to get motivated from. If the diagram keeps growing in content, there is always some new motivation to get. However, this put the barrier at the users. If a user is only open for a small amount of options, motivation can still run out. But for a passive approach, I believe the Improvement Identifier has plenty of possibly to convince people to open up to new options.

6.2.3. Criteria from Users

From talks with startup founders 4 groups of criteria for an eco-design tool were identified. The first group of criteria is named 'an appropriate level of expertise', which includes not difficult but also not too obvious. Masui, et al., (2003) noted that the QFDE is easy in its use for people without prior environmental knowledge. That the Improvement Identifier is also not too obvious, is confirmed by participants of the iterative tests, who mentioned that new unexpected insights came to light with the tool.

The second criteria is 'low time investment'. In comparison to other tools the QFDE stores a little higher than average on time required (Bovea and Pérez-Belis, 2012). Although, I would argue that this depends on how complete you want to be in your use of stakeholders' benefits and business model features. It is quite easy with this particular tool to expand the data over multiple session and spread out the workload.

The third criteria is 'clear applicability to startup'. Showing all startups their personal applicability is impossible, which is why the Improvement Identifier Canvas make use of the principle of personal opportunity identification (Hallstedt, et al., 2013). The tool provides a setting in which

the startup founder can discover the opportunities of eco-design form himself, and via this path he builds up an idea of how it is applicable to his own startup.

To satisfy the final criteria group ‘multi-layered flow’, a tool should have the ability to ‘flow’ between prioritisation, holistic view and quick glance. Wasserman (1993) confirms that QFD enables prioritisation. Furthermore, a holistic view is also achieved, since the tool can keep track of many interrelations of a business (e.g between stakeholders’ benefits and business model features), Thus to look at the canvas, is to see a holistic overview of a business. The third layer, quick glance is about the ease of communicating the content of the tool, which is something QFD excels at according to Akao (1990). Participants of the iterative tests recognised the benefit of the tool for communication as well and also mentioned how it could help prioritise for future, bringing the topic of multi-layered flow full circle.

FUTURE DEVELOPMENT

Because of the time restrictions of this project not all details can be fully developed. This chapter contains ideas on the future developments of surrounding the improvement identifier canvas. The first section about bringing the tool to the users and what the potential business behind that could be. The second section details some of the tools that could be used as a follow-up of the IIC.

6.3.1. Deployment

An observation from other business canvasses is that often the knowledge about them is shared in three ways: a guide book, website, or workshop. A slide deck has been created for the Improvement Identifier with which holding a workshop is feasible.
Although, I want to focus on the website. This specific tool offers many possibilities with a website. The obvious use of a website is to have a location that people can download the canvasses from. However, users could have a lot of benefit from a digital Improvement Identifier.
A digital version would do the calculations for you, but more important you could add extra cells to your canvas if you gain new customer insights or the complexity of your business model is expanding. And iterative use of the tool becomes even more attractive. Having to redo a paper canvas with every iteration you make as a leans startup is time consuming, but with a digital version you can keep build on it. Simultaneously, logs could be created of your iterations, so you haven't lost any information, if you might need to take a step back with your business.

Viability

Building a website would have some cost attached to it. An easy way to cover for this is asking a fee from users. A common practice for online business tools is to have the tool free until a certain limit has been reached in the use. For the Improvement Identifier this could for example be that the amount of cells is limited when you are using the free version.
Generating incoming from the tool might actually be a necessity. It is posed that some aspects of the Change Diagram might become inaccurate over time, furthermore this diagram is by far from a complete representation from the possibilities.

Some income could help maintain the Change Diagram.

Extra Incentive

As discussed, the research field about the relations between eco-design and startups is still immature (Choi and Gray, 2008). Observations about the use of the Improvement Identifier by startups could be valuable to expand this field. One incentive for startups to share some of their user data could for example be a discount on the fee of the digital version.

6.3.2. Toolkit

Some ideas have been created for additional tools to be use after the Improvement Identifier Canvas. However, due to time constrains it was no possible to develop these ideas in full and to test them. This section is a short summary of some of the ideas to get a feel of the further opportunities possible within the framework the solution is build.

Adjustment Processor Canvas

This canvas is the direct follow-up of the Improvement Identifier. If someone doesn't know how to kick-off implementing a change, he can go to this canvas. With this canvas insight is gained on which features of the business model are most open for change. However, we don't want people change a single feature, since eco-design requires a holistic approach (Geissdoerfer, et al., 2017). This is why the user also has to assess the interrelation between the features. The assumption is that this could lead to whole system changes instead of single features.

The steps are:

1. Check if your business model features on the Improvement Identifier are sufficiently detailed.
2. If you add extra business model features, redo step 11 of the Improvement Identifier.
3. Make the sum of scores at #11 per feature. This is the openness for change.
4. Put all the feature on both the X and Y-axis of a grid.
5. Grade the interrelation between features
6. Calculate the outcome of the grading
7. Multiply those scores with that of step 3 to get the ultimate openness for change score.

Iterative Progress Assessment

One important aspect of this paper's research is the Lean Startup method. The aim is to introduce eco-design via the Lean Startup method, which means that the solution should be able to work in the framework of this method. From the Improvement Identifier canvas it might not be directly clear how the canvas applies to the iterative development approach of Lean Startup (Ries, 2011).
The Iterative Progress Assessment is the next step after an iteration has been made with the output of the Improvement Identifier. The output of

the Improvement Identifier is an eco-design change the business wants to make. The goal of this add-on is to assess if the satisfaction of the stakeholders has improved with the new change in place.
Executing the Iterative Progress Assessment is fairly simple:

1. Add a stakeholder at #5 on the Improvement Identifier canvas: your company.
2. Add the benefits related to the change (see Change Diagram) to the applicable stakeholders at #6 on the Improvement Identifier canvas
3. Redo the steps 7, 9 and 10 of the Improvement Identifier canvas.
4. Assess if the scores at 10 have improved compared to the previous iteration.

Requirement Sourcing

It was noticeable during iterative tests that participants don't always have a grounded reason why certain stakeholder requirements should be included and what the importance of the requirements should be. In the use of the Improvement Identifier this will affect the score of the business model features as well, which could lead to an incorrect prioritisation of the features.

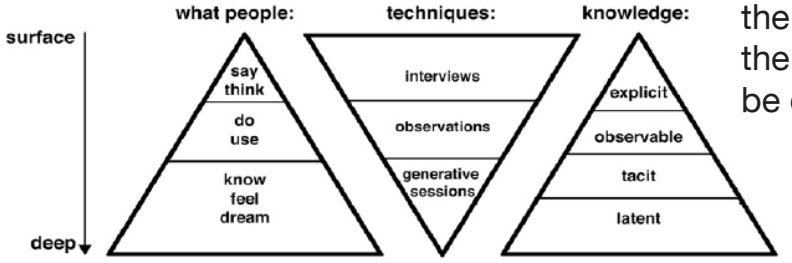


Figure 6.3-1: how to access different levels of knowledge (Visser et al., 2005).

Requirement Sourcing is a simple addition to the Improvement Identifier to resolve this.

1. Per requirement give a score on how high you believe the source is in delivering quality data.
2. Per requirement assess how the informations is acquired. Have a look at figure X, if the information comes from a deeper level the score is higher.
3. Multiply the score of step 1 and 2. A lower score means it probably should be double checked.

To show this tool's relevance to eco-design, we take participant 3 of the iterative test as an example. In the eco-tool two stakeholders were used by the participant, customers and users. He stated that the user didn't care about the environment and all environmentally requirements of the customers were ranked the lowest from all listed requirements. When asked about the sources for these insights, he said that all of it was told to him by a customer. Looking back at figure X, such information would be on the explicit level. With three levels below it, there are chances that this is just the surface appearance, but that a more in-depth research would show some interest in environmental criteria. It is similar as was found for the startups, your mindset can be in the way of seeing the benefits that can be offered (Lourenço, et al, 2012).


Phase 1 Identify Improvements
Phase 2 Mapping your Business Model
Improvement Identifier Canvas
Phase 3 Linking the Present to the Future
11. Relation Grades
12. Scores
10. Scores
5. Stakeholders
6. Benefits
Changes
High = the proposed change is highly likely to be realisable within the feature.

7 SOLUTION CASE STUDY

This chapter describes the test of the final design. The test is conducted by means of a case. The case describes a fictional startup and business model, which test participants used in conjunction with the created ‘Improvement Identifier Canvas’. The aim of the study is to provide a more conclusive result on the tool’s ability to push a startup towards the use of eco-design and the fit with the Lean Startup method.

Case Study 7.1

INTRODUCTION

The iterative tests, that led to the final design presented in chapter 6, didn't provide a clear cut answer about the design's ability to push a startup towards the use of eco-design. For the final design this means that the user of the tool should feel the incentive of proceeding with an eco-design business change in future business development. The aim of this study is to realise a more conclusive outcome on the abilities of the 'Improvement Identifier Canvas'. The research question for this study is: Are people triggered to adapt a eco-design change for the business model?

However, an eco-design change on itself is not good enough, since the goal of this project is to have the method applicable to lean startups. There are two essential elements to assess this. The use of the Lean Startup method requires iterative validation cycles. These validations have as a higher aim to create benefit for the customers. For this reason, a second question is asked:
Are the outcomes of the method useable for further validation cycles with the customers?

RESEARCH QUESTION 1

Are people triggered to adapt a eco-design change for the business model?

RESEARCH QUESTION 2

Are the outcomes of the method useable for further validation cycles with the customers?

METHOD

For this test a case approach has been used. In previous tests startup founders used their own business to make use of the tool. For this study a case is written about a fictional startup. The case (appendix D.1.) includes the business model (incl. the product), views of a variety of stakeholders, and the business operations. The product example is a headphone with the gimmick of being safer for use in traffic. The test participants are asked to put themselves in the role of one of the decision makers at this fictional startup. Participants will be free to usethe information of the case however they see fit, but they aren't allowed to search for extra information to include in the case. The expected use is that the case information on 'business operations' is used for step 1 of the Improvement Identifier Canvas, 'views of stakeholders' for step 5, 6 and 7, and 'business model' for step 8.

After the use of the Improvement Identifier Canvas with case, participants are asked to fill in a questionnaire (appendix D.1.). The participants are asked, in their role as startup decision maker, about their likeness of pursuing one of the changes they explored with the canvas. This followed up by them being able to choose if they will pick a method to realise the change from the 'Change Diagram'. For both parts the participants are asked to give a grade on a scale from 1 to 5 and to write what change and/or method they are most likely to pursue. The questionnaire is closed off with their personal experiences to assess if any unclarity in the materials could have led to unexpected outcomes.

Each participant is provided with the 3 sheets of the Improvement Identifier Canvas, 2 extra sheets for if more space is required and the printed slide deck with the instructions of Improvement Identifier Canvas. Due to its size, the 'Change Diagram' is accessible for the participant at the provide computer.

Figure 7.2-1: Example product used, headphones with the gimmick of being safer for use in traffic.

Participants

Participants are picked from master students of Delft University of Technology. However, students of the faculty of industrial design engineering are excluded since they are assumed to have pre-existing knowledge on eco-design based on the curriculum at this faculty.

7.3 Case Study

RESULTS

The case study was conducted with six participants, of which five men and one woman. All participants are students from Delft University of Technology and are within an age range of 23 to 27 years old.

Some participants experienced a little bit of confusion with some materials, yet it was within manageable bounds. It can be fairly assumed that all data output can be taken into account.
The output per participant is summarised in appendix D.2. In Appendices D.3 to D.9 the filled out Improvement Identifier Canvas and questionnaire is included per participant.

Eco-Design

This is related to research question 1.

At step 2 of the Improvement Identifier Canvas, participants are asked to state changes they would consider making to the startup. At this stage every participant at least mentioned 1 change related to eco-design. In the questionnaire they were asked about their preferred change to pursue, from these answers half of the answers was related to eco-design.
On the question, “How likely would you be to pursue one of the changes you stated at step 2?”, the average outcome is 4, which means a high likeliness of a change being pursued.
Of the changes the participants states on the canvas, they said they would consider pursuing 2 to 4 of the changes.

On the question, “Would you consider choosing any of these ‘methods of realisation’, if you would be proceeding with changes to your startup?”, the average outcome is 4, which means a high likeliness of considering one of ‘methods of realisation’. The follow-up question was what the next steps for the startup would be and if applicable, how ‘methods of realisation’ would fit in those steps. 3 out of 6 participants chose to start the realisation of an eco-design method, which notably was modular design all three cases. From the other participants, one didn’t provide an answer, another wanted to focus on marketing and a third proposed a strategy that is debatable on its eco-design impact. It is debatable, because he wants to solve the problem without the product, which would reduce environmental impact, however the proposal about spreading awareness that was given, didn’t seem related to building a startup business around. This would mean it moves out of the scope of this project and the Improvement Identifier Canvas.

Lean Startup

This is related to research question 2.

At step 1 of the Improvement Identifier Canvas, participants are requested to write improvements for the business. 5 out of 6 of the participants wrote at least one benefit that also can positively affect the customer.

Most improvements and changes proposed by the the participants are useable within the fast iterative loops of the Lean Startup method. One participant suggested to increase quality of the product by being longer in the development process before a product launch, this could negatively affect the speed of a lean startup. Another participant wanted to follow a direction that potentially could have a mismatch with the Lean Startup, since there was no clear business model applicability in the proposed direction. The change proposed was to improve the awareness of problem, which is not a sellable product on itself.

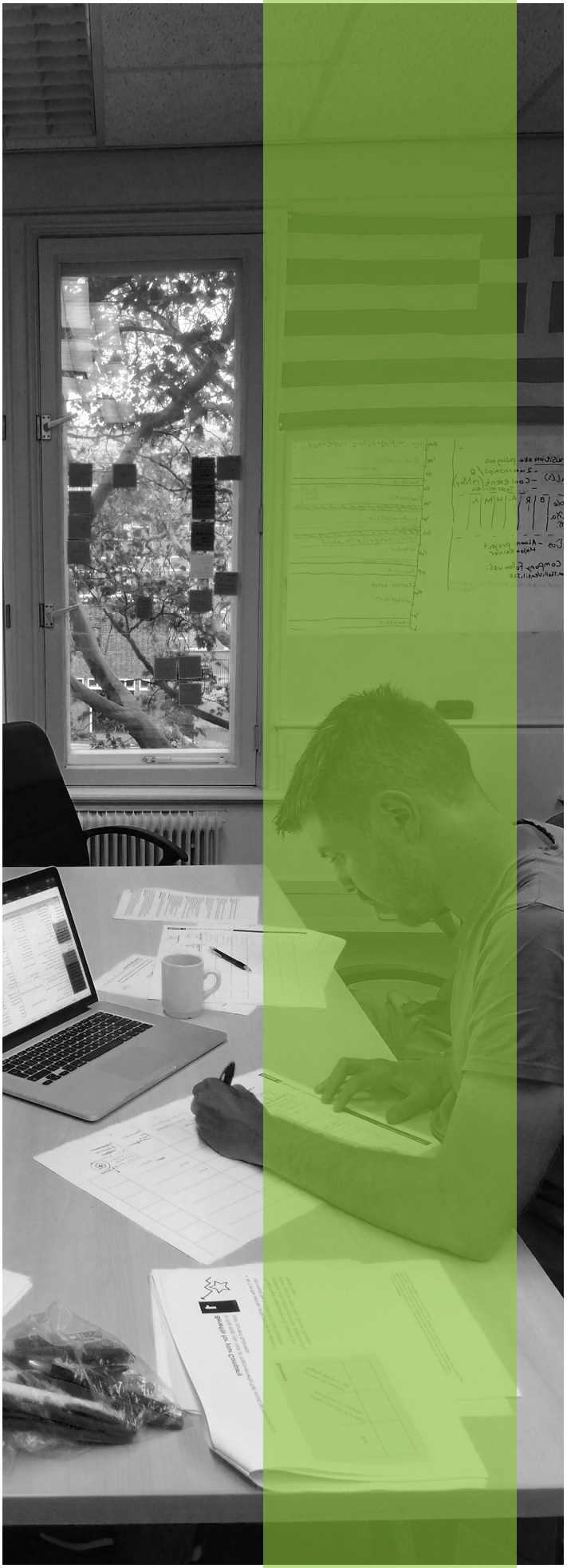


Figure 7.3-1: Particpant using the Improvement Identifier Canvas.

7.4 Case Study

CONCLUSIONS

This research was conducted to make a better assessment about the Improvement Identifier Canvas capabilities to induce eco-design changes for lean startups. To make this assessment two questions are posed.

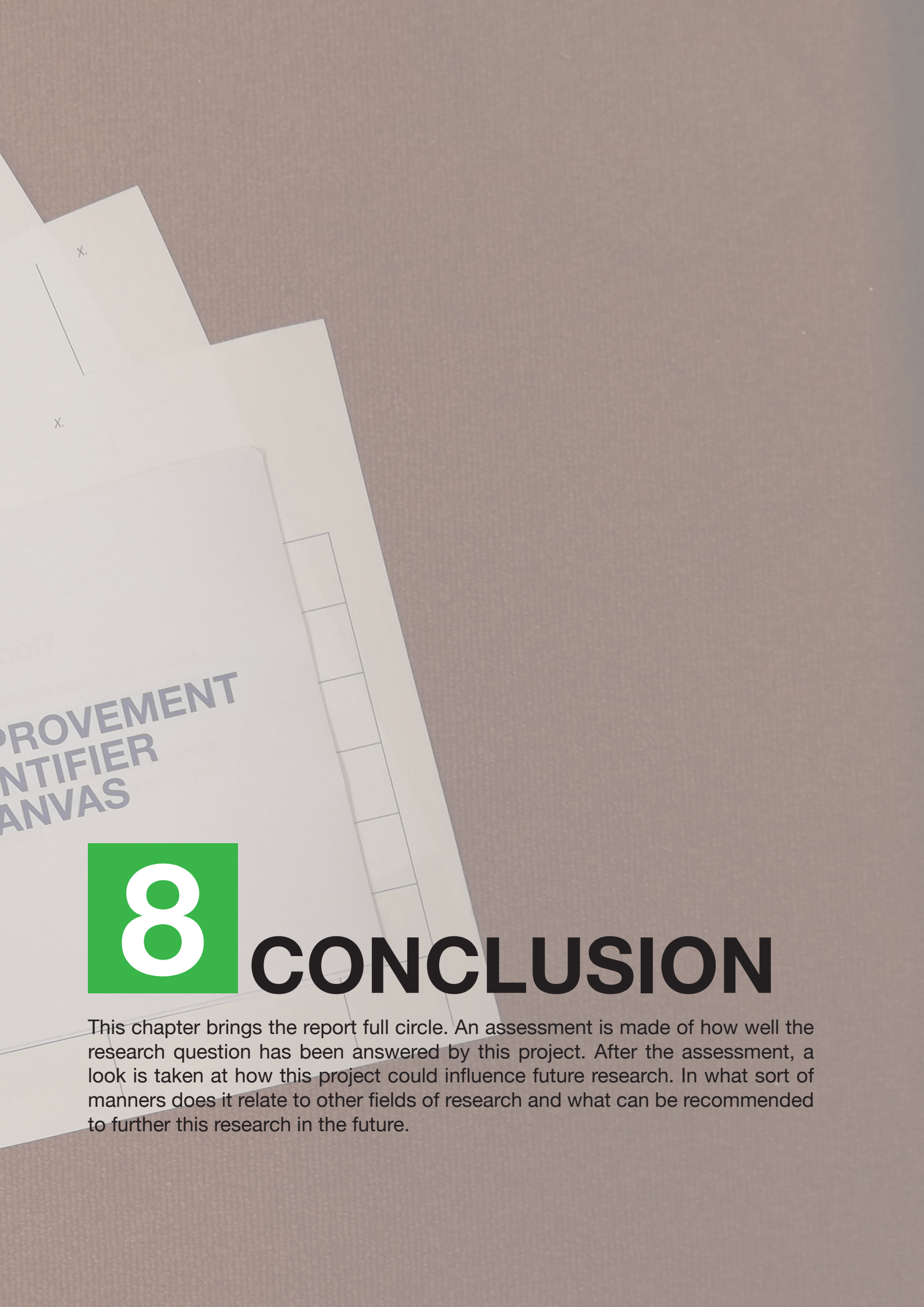
Related to the lean startups is the question: “Are the outcomes of the method useable for further validation cycles with the customers?”. The results show that the improvements and changes the participants proposed generally are useable with the cycles of the Lean Startup method. Next to that, the improvements they want to make to the startup business can have in 5 out of 6 times a positive outcome for customers as well.

To assess the Improvement Identifier Canvas viability for introducing eco-design in startups the following question was asked: "Are people triggered to adapt a eco-design change for the business model?”. From the original proposed changes to the methods creating change there is a little decline in eco-design focus. Nonetheless, half of the participants stated they would use an eco-design method in the next steps of the startup.

Both questions received fairly positive outcomes, which to conclude means that the Improvement Identifier Canvas has a good chance of introducing the use of eco-design methods in lean startups. Although, the results of this study have to be taken with a pinch of salt, because the test participants aren’t facing the same barriers as the startup founders. In particular in the effect of escalation of commitment (chapter 2.4.2.), which makes managers of a project clamp to the current course of the project, even if newly acquired information would overwhelmingly prove than the course needs to be adjusted. This effect is especially strong for some that started the project, like a startup founder.

As a last note, the purpose of this test was not to improve the tools, although some small adjustments have been made based on observations and notes from the participants.


Phase 1 Identifiy Improvements
Phase 2 Mapping your Business Model
Phase 3 Linking the Present to the Future
1. Improvements
2. Business Chang
Changes
Improvement Identifier Canvas
by M.J.H. Kersten
Part of the
Iterative Business
Enhancement Toolkit



8 CONCLUSION

This chapter brings the report full circle. An assessment is made of how well the research question has been answered by this project. After the assessment, a look is taken at how this project could influence future research. In what sort of manners does it relate to other fields of research and what can be recommended to further this research in the future.

8.1 Conclusion

RESEARCH ASSESSMENT

This report poses the question; 'how can eco-design methods be brought into startup practice by introduction via the Lean Startup method?'. Let's dissect this question by answering it first in two parts.

8.1.1. Eco-design methods brought into startup practice

Looking at this statement word for word, one could say that the this report does not succeed in answering it. This is because the designed tool, the Improvement Identifier Canvas can't be really considered an eco-design method on its own. However, it is a tool that facilitates bringing eco-design methods into the practice of startups, thus indirectly the goal is achieved.

As Carlile (2002) notes, if the difference in knowledge between two parties is too large a boundary object is required to bridge the knowledge gap. In this case it is the academics, that have create the eco-design methods, on on side, and the startup founders on the other. From the literature and user research it is apparent that startup founders don't grasp the benefits of eco-design, while simultaneously academics don't take the potential users of their eco-design methods sufficiently into account (Rossi, et al., 2016).

The Improvement Identifier Canvas as a boundary object works as a translator between the two parties. The academics can focus on what they do best, and developed the methods. The Improvement Identifier translates the principle and use of the methods into benefits and actions that can be understood by the founders. Furthermore, because the Improvement Identifier makes use of the principle of opportunity identification (Herrmann, et al., 2008; Volkmann, et al., 2009; Lourenço, et al, 2012), every user is able to explore personally what the benefits of eco-design mean to them. The personalisation makes chances of acceptance of the new knowledge much higher.

The outcomes of the final test also look positive. With from the onset almost everyone entertaining the possibilities of eco-design, and eventually half of them deciding they want to follow-up with changing their business with the help of an eco-design method.

8.1.2. Eco-design introduction via the Lean Startup method

The Lean Startup method was chosen as the method for introduction, because it allows for efficient use of resources. This would allow startups to reduce risk of spending too much resources on exploring a new direction.
For the first use, the amount of resources needed to explore new directions, is low with the Improvement Identifier Canvas. However, no actual tests are held to see how canvas would hold up with multiple iterations. It is believed that the resource cost would only go down, since the tool is not repeated from scratch, but can be easily expanded in information content over time.
Nonetheless, at this moment the strength of the fit of the improvement identifier canvas with the Lean Startup method is only a promise. There is no proof to confirm this part of the question.

8.1.3. Concluding

The outcome of this research does not contain an eco-design method. However, it seems to be excellent for introducing new concept to people. Yet that was not the full research question that was posed.
To conclude, the outcome of this project is showing how eco-design can be introduced to startups.
There is no information known over what would happen after the introduction. There are two main open questions: Would startups use the tool iteratively? Would the startup follow through with bringing an eco-design method into practice?

RECOMMENDATIONS & IMPLICATIONS

8.2.1. Implications

For its research this report focuses on startup, however the touch point with eco-design is via the Lean Startup method. The Lean Startup method can be used in any project. This means the results of this report are not limited to startups alone.

Since the Improvement Identifier only introduces eco-design, and does not change anything about eco-design methods themselves eco-design might also be replaceable for another approach.

8.2.2. Future Research

The choice to focus on the introduction of eco-design to startups was not based on any like between the two. It means that this kind of research can be expanded in two ways. First an other issue, instead of eco-design can be chosen. For example ethical design or social design.
My advise is to choose an issue that has clear practical application. The word design attached to it often gives this indication. For an issue without practical applications it might be difficult to uncover the benefits that can be offered by bringing it into practice. Often morality alone is not good enough, it was the same with eco-design for startups. There is a select group that started of like that, but convincing a startup to become an eco-startup is nigh impossible.

The second way to continue this research in a new direction is to replace startup by another company form. The use of the Lean Startup method is also becoming big in corporates, maybe they would be open for exploring such a direction.

8.2.3. Recommendations

It is worthwhile to explore further what the benefits are that can be offered by different eco-design methods. Building up a more extensive library, naturally makes it more likely that anyone can find a helpful method, but also it is important that people won't be too disappointed if change doesn't deliver the expected value. In such a way there could be some unintentional impacted caused by such a tool.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ecotap
Team Canvas
rockstart.
we love startups
rockstart.
we love startups

9 DISCUSSIONS

This chapter is a reflection on the processes of this project. First the limitation of the research are discussed, which entails how I personally might have influenced the research and how the three conducted sub-researchers could be flawed. The second part goes more in-depth on the overarching process. The initial ideas and motivations are brought into relation to how the project was eventually executed.

9.1 Discussions

LIMITATIONS OF RESEARCH

This chapter discusses how some information this project outcomes could be limited in its validity. It is difficult to remove all biases from a research, however I can make notes of potential biases that have slipped into the research. Up for discussion are the academic sources, user research, iterative testing and case study.

9.1.1. General

A common advise for academic research is to have multiple researchers involved to remove biases, however in the scope of this project this wasn't an option. Because of this, I believe it is relevant to address how my own background could have influenced the research. I have worked for three different startups, all in different roles. I was product manager, marketing manager and market developer. My field of study as strategic product designer also taught me a lot about the practices of starting a business and how a business hold run. Based on the experience it could be that I have made subconscious interpretations on the research content. I strongly advise to have other academics check the validity of the research, or even repeat one of the sub-researches.

9.1.2. Academic Sources

The validity of some sources can be taken into question, because of the date of the research. Potentially most affected by this are sources that use a qualitative approach for gathering data from a small target group. For example, Schick, et al. (2002), describe issues that startup are experiencing. One of the frequent issues is the difficulty of early phase planning of the business. However, since 2002 the digital options to maintain a planning have improved and new methods to manage a startup, like the the Lean Startup method (2011) have been introduced. It is quite likely that some change, in for example these experienced issues, might have occurred.

One could look for a more recently dated source, but unfortunately some fields, in particular startups and startups using eco-design, aren't

frequently researched. An action that I have taken in anticipation of such flaws in sources, is to mainly focus on the principles behind insights. For example, instead of addressing all different ways a startup could have issues with dealing with its resources, I brought it to the fundamental resources in chapter 2.1.

Insights regarding eco-design might be time constrained, meaning that it could disrupt some of the groundwork of this project. Rousseaux, et al. (2017), found that the amount of tools tripled over the last 15 years. Furthermore, the focus of design for sustainability has shifted over the last 30 years. (Ceschin and Gaziulusoy, 2016). Which shows that the eco-design field can be a bit volatile. Nonetheless, it is not expected to affect the introduced tool, Improvement Identifier Canvas, since on itself it has no eco-design foundation. Rather the secondary tool 'Change Diagram' is expected to require adaption over time. Newly introduce eco-design methods can be added and links have to be established to benefits for the companies.
The benefits in the Change Diagram that are currently deemed relevant could also prove to be just part of the contemporary mindset. The global mindset about environmental sustainability is nowadays notably changing, because of the effects of climate change among other.

9.1.3. User Research

With a total of five, the amount of participant for this research is on the low side. With the method used for this research that is not per se an issue on itself, but normally the trade-off would be between the richness of insights and participant amount. There was some good content found to continue the project, however the conversations were maybe still a little bit too surface level. More in-depth information might create a more clearly focused outcome.

9.1.4. Iterative Testing

It was difficult to find participants for the iterative testing. Two participants even mentioned that they get many requests to participate in tests, but that they don't want to spend their valuable time on it. One added that he accepted to participate, since the topic seemed interesting and potentially beneficial to him. The benefits hinted towards to get them to participate might already have primed them to be open for the possibilities the tool has to offer.

In all iterations, participants were instructed to only write a few notes per step, so test could be fully conducted in the hour that was made available for it. These instructions could have led to participants not being too creative. Like for example with a brainstorm session, you also need to empty your

mind of old ideas, before you can start creating new ones. The level of new insights gained by the participants was indeed declared as mediocre.

9.1.5. Case Study

One noticeable observation from the test was that half of the participants concluded with the use of modular design. Perhaps this is related to modular design also being on of the examples in the instructions of the Improvement Identifier Canvas. Another cause could be that it is due to the placement in the 'Change Diagram'.

The participants used the tool as it is supposed to be finally used by startups, however for the set-up of the test another order of steps might have been better. At step 5 until 8 on the Improvement Identifier Canvas the participants were supposed to use the information about the current business described in the case provided to them. But since the tool starts with the changes to business, they were confused about how much of those changes should already be reflected in what they wrote in steps 5 to 8. For another iteration of this test, I would advise switching the order of the steps.

REFLECTION ON THE PROCESS

From the onset, this project was predicted to be challenging. The challenge lies mostly in the two fields of research, eco-design and startup practice, that this project aimed to link. According to my findings, the academic field of startups is still immature, while the field of design for environmental sustainability is quite extensive (Rousseaux, et al., 2017). Furthermore, research on the two fields overlapping is also limited (Choi and Gray, 2008) and mainly focused on eco-startups, which are out-of-scope for this project. As an effect there were three sub-challenges that needed to be faced: focus, Lean Startup approach and overestimation.

9.2.1. Focus

To address the focus, I split the challenges in the two areas I needed to focus on: startups and eco-design.

Startups

Around halfway through the project a realisation hit, I was not on track to resolving the research question. The research questions states that the introduction of eco-design should go via the Lean Startup method, yet I became aimed at introducing eco-design to startups in general. On reflection, I believe the cause started as an effect of the academic field of startups being immature, the best practice of a popular method like the Lean Startup method appear synonymous with the practices of all startups. As a result, it seemed like satisfying startup requirements satisfied the requirements like to the Lean Startup as well.
Nonetheless, because of these setbacks I believe I have created a better understanding of the inner-workings of these young ventures, which was one of the personal goals of this project.

Eco-Design

Since the field of eco-design is extensive, the links between all the information make the situation inherently complex. I tried many kinds of mind maps to create a kind of logic for myself between the pieces of information, but reflecting on it now it was very improbable for me to form a coherent story from all content. After all, a story is mainly progressing in one direction, but if you want to mention many of the interrelations between sources, the main direction of the story

will be lost. And even a research report follows such a text format.

Instead of creating comprehension in the complexity, a method is to create a focus and scope down the project. However, I had a hard time realising such a focus, which I think was partially a fear of failure and also the lack of an existing startup and eco-design link. To first address the lack of the link. For many eco-design methods the benefits they could offer to a company are unclear. At the same time, I didn't know yet what the benefits the startups would be interested in (and I needed to avoid being biased by my own experiences with startups simultaneously as well). The path that follows from this is to continue the research for a bit longer before deciding on a focus.

The other option is to take a leap of faith and just go with a direction, but here I was fearful that I might choose wrongly and as a result of that loose time. Now I ended up going with the first, which obviously also costs time. My feelings are still split if it was the right decision, although something else says I actually did choose incorrectly: the Lean Startup method.

9.2.2. Lean Startup Approach

The Lean Startup method (Ries, 2011) states that you should take the leap of faith. Failure should be embraced, because even a negative outcome will have provided new learnings. At the start of this project I indeed did decide on using the Lean Startup method to tackle this project. The choice to do this was actually highly motivated by the need for an approach that can deal with the complexity of the literature of this topic. But where did it go wrong?
I think I overestimated how well I understood the Lean Startup method, when I decided to use this approach. For example, halfway during the project I realised that I was not reflecting on a regular basis on my progress. Even though, reflection is a key aspect of learning, which is one of the three elements of the Lean Startup (Ries, 2011).
The biggest impact on the project progress, I believe, is my misunderstanding of how the customer focus should be handled. I tried to satisfy the needs of as many people as possible. This might be an effect of how I am used to handle customer needs with traditional industrial design methods. But for going lean, just satisfying a couple of people is enough (Blank, 2013). Such an approach would have greatly diminished the complexity in the early phases of the project.

9.2.3. Overestimation

Like I overestimated my knowledge about the Lean Startup method, I believe I also continuously overestimated how much I can achieve in a period. This has affected the planning drastically.
I know that I am bad at personal project planning and even stated this in project assignment as a goal to improve. However, from the beginning I might have set the bar too high. I tend to put a too idealistic image of the outcome in my mind when it comes to design. A desire to create the perfect solution. For example, in the project brief I estimated I would be able to even scale up the solution towards non-startups. Eventually my overestimation with bad planning skills led to milestones being continuously behind. I believe this is also the main reason for bad communication towards the supervisory team. Often I felt at meetings like I was not ready to present something, lacking behind.

9.2.4. Concluding Learnings

There is no reset button on the project. To redo it and this time tackle the challenges in the right way. Nonetheless, it can be seen as a valuable learning. For me personally I have learned to better understand what tendencies I have when I am executing a project of this size on my own. These are good insights to take further in my future work life.
But it doesn't only have to be a learning for me.
Since the field of eco-design in lean startups is in its infancy, future researcher can learn from my experience and avoid the same pitfalls. I hope people will continue this field. I truly believe that introducing eco-design in the young ventures eventually will have the largest environmental beneficial yield for our planet.

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APPENDICES

A. Yes!Delft Responses — Chapter 2

B. Empirical User Research — Chapter 3

1. Profiles of Participants & Startups
2. Interview Guide 1
3. Interview Guide 2
4. Code Tables

C. Iterative Testing — Chapter 5

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3. Instructions for Iteration 1 & 2
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9. Materials of Participant 1
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D. Solution Case Study — Chapter 7

1. Forms for the Participants
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