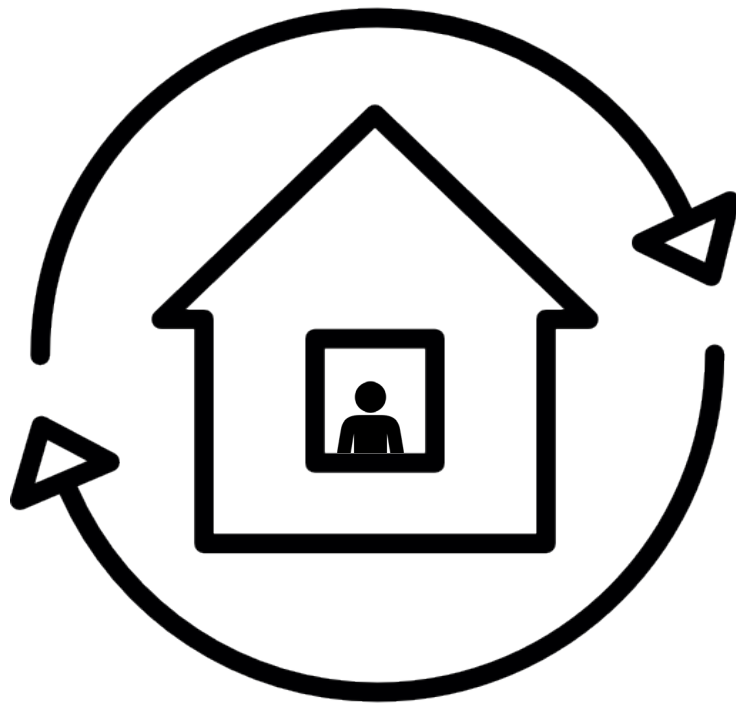# THE   NEXT   STEP
IN CIRCULAR HOUSING

An exploratory user-centred research into the relationship between design and circular behaviour of students living in student housing complexes.

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ABSTRACT

Earth's resources are being depleted which creates a need for a transition towards a circular economy. This transition brings multiple challenges and requires new behaviours. However, in current design practice, the focus lies on products and materials, not on the required circular behaviours.

The goal of this research is to describe the relation between design and circular behaviour. To do so, a flexible analytical framework is created based on a literature study, which can be used to perform an empirical study in any context for any behaviour. The applicability of the framework is tested in this initial exploratory research of which the scope is focused on the circular behaviours of Reuse and Recycle Materials of students living in student housing complexes. The framework is filled in with document analysis on the context and semi-structured interviews with the inhabitants of the cases.

The results show that a design has influence on behaviour. A design can make behaviour impossible by having a negative influence on one or more of the three categories of the COM-B theory. A design can also make a behaviour possible, by changing the categories that are negative into positive. In between the two extremes of possible and impossible there is also the degree of the categories that influence behaviours. Someone could be able to show behaviour, but if it takes too much effort the person can refrain from showing the behaviour. If there is a high degree of capability and opportunity, it can motivate a person to show the behaviour, and likewise a low degree can demotivate. Therefore a design should strive to have a high degree of capability and opportunity for a behaviour that is desired.

However, it must be noted that behaviour is a complex phenomenon with a multitude of factors that influence it, both conscious and unconscious. It is difficult to map all the different factors for every person. Not all factors are related to a design, there are also beliefs and values which have a major influence in behaviour.

PREFACE

This master thesis is written from the perspective of Real Estate Management. It is written for the master track of Management in the Built Environment (MBE) at the faculty of Architecture in the Built Environment at Delft University of Technology.

During the bachelors and master I have always strived for sustainable designs. When I started my studies in 2016, I wanted to make energy neutral and modular buildings. But as the years passed and more knowledge had been gained through the master, I learned about circularity and its multiple challenges and its noble cause to save the planet. I decided that I want to help in the transition towards a circular economy and have seen a gap in building design that I wish to address.

In the six years I have been living in Delft, I have moved five times. And from those five, three were in studios and in two if those I was living with two or more people. While living in the studios, I would not separate my waste, I would have the heating on a high level, use a lot of water for dishwashing and some more things I am not proud of, but I would also reuse disposed materials, such as tables, chairs, and cabins. But when living with three other people, one of my roommates put a lot of effort into making separate trash bins and informed us on how to separate waste. He would also turn the heating down and ask us to not turn on the heating over 18 degrees Celsius. This resulted in more sustainable behaviour as a household. When visiting a friend, I noticed that the building he lived in has a place where people offer furniture or other materials in the entrance hall, before throwing it in the trash or sending it to the kringloop. All these experiences combined with circular insights got me thinking. How do designs influence circular behaviour?

I would like to thank my mentors for their enthusiasm, guidance and critical feedback. For cheering me on in difficult times of the research. They made the process of writing a thesis much more enjoyable!

I hope you will find this research interesting and that it will inspire you to join on the journey to transitioning to a circular economy!

Kind regards,

Teun Lagestee

Student number 4443543

Delft, 17-05-2022

"We shape our buildings;
thereafter they shape us"

-Winston Churchill, 1943

EXECUTIVE SUMMARY

Introduction

In the Netherlands, in the current transition towards a circular economy, a lot of effort is being made on redesigning products and materials in a way that they become circular (Ministerie van Infrastructuur en Waterstaat, 2021). Also new services are invented which allow for the circular use of products (Rexfelt & Selvefors, 2021). However, there is a missing link. If buildings are made of circular materials but no changes are made in the lay-out, the building can still act as a threshold to its users to show circular behaviour. In a circular society people have to collaborate to ensure that all materials will end up in the right and most sustainable place (Selvefors, Rexfelt, Renström, & Strömberg, 2019). By only focussing on making materials circular so that they can be used in a closed loop, but neglecting the part of what this will actually look like in everyday life, an important part is being left out of the equation. People should be enabled to show circular behaviour from their home, in the office, or in a public place.

This thesis produces a framework that can be used to research different behaviours in different contexts. In appendix A, a 10-step method is explained to replicate the study for any context. The other appendices serve to smoothen the process of replicating the study.

In this thesis, a suggestion is made on the relationship of the design with the specific circular behaviours of Reuse/Resell and Recycle materials in the studied cases. By performing multiple case studies, best practice advice can be given on what aspects of design should be recommended and which should be avoided. The built environment can be changed based on this research by stimulating people to have a lower environmental impact through their behaviours.

The problem statement can be summarised in the following bulletpoints:
-Earth's resources are being depleted (Global Footprint Network, 2021)
-Waste has to be separated more (Milieu Centraal, 2021a)
-Need for transition towards circular economy (Ministerie van Infrastructuur en Waterstaat, 2021)
-A circular economy challenges and requires new behaviours (Wastling, Charnley, & Moreno, 2018)
-In current design practice, the focus lies on products and materials, not on new behaviours (Kanters, 2020; Berg, Voordijk, & Adriaanse, 2019; Wastling et al., 2018)
-There is a knowledge gap on how design can influence behaviour to be more circular in the built environment

The main question of this research is: "What is the relation between design and circular behaviour?". To stimulate advancements in design for circularity, this research will look into the relationship of circular behaviour with design. First a literature research is done to gather theoretical knowledge based on which a framework is made to perform empirical research. By first defining circular behaviour, then looking into behaviour models, and finally on designing for behaviour change; the framework is made with which case studies and interviews are done to research this relationship in practice.

Literature study

The first part of this research is a literature study to answer the first four subquestions to prepare for the empirical study.

SQ1: "What is circular behaviour in the built environment?"

To answer this question a definition of circular behaviour is made which is then filtered down to actions a user can do. A short definition of circular behaviour is: Value retaining behaviour that leads to closing and or slowing circularity loops.

A longer definition that focuses on consumers is: Value retaining behaviour that leads to closing and or slowing loops such as Refuse, Reduce, Resell/Reuse, Repair, Recycle materials and other behaviours that help circular business models function.

In table 3 examples of circular behaviours of users according to Vermeulen, Reike and Witjes (2018) are presented. In this research it is chosen to focus on the behaviours of Resell/Reuse and Recycle Materials.

Type of behaviour	Example bevaviour
R0 Refuse	-choice to buy less, or use less; -reject packaging waste and shopping bags
R1 Reduce	-using purchased products less frequently; - use them with more care and longer.
R2 Resell/re-use	-buying second hand, or finding a buyer for a product that was not or hardly in use, possibly after some cleaning or minor adaptations restoration; -use online consumer-to-consumer auctions for used products
R3 Repair	-by the consumer in their vicinity, or at their location, or through a repair company; -or at a 'repair café'
R7 Recycle Materials	-give back as separate waste streams

Table 3: Excerpt from table 2 (Vermeulen et al., 2018)

SQ2: "What factors influence behaviour?"

The literature review provides multiple theories of behavioural models. The models are categorised into different goals and contexts. Even though none of the models will provide a 100% accurate prediction on what behaviour will actually take place, they provide valuable insight into factors that influence behaviour. Out of the many models, it is chosen to use the COM-B model as a building block for the framework. The COM-B model addresses many aspects that are mentioned in the found theories and simplifies them into three main and six separate subcategories. The theory contends that when the three main categories are positive, a behaviour is shown. This makes it possible to research if there are negative aspects that prevent a behaviour from being shown, and what aspects are positive that stimulate a behaviour. This simplification into six researchable subcategories allows for easy implementation in research.

SQ3: "How does design influence behaviour?"

As found in sub question 2, there are many factors and different theories for explaining behaviour. However, there is not one model that provides the final answer to the most important factors that determine behaviour. So it depends on the desired behaviour context and on the individual, which models would be of the best use. When designing for behaviour change, it is important to first pick a desired set of behaviour that has to be influenced. After deciding on the behaviour, use of a behavioural model is necessary to determine the most important factors to manipulate with a design. In the literature review research on Design for Behaviour Change from Niedderer et al. (2014), there are four main approaches to designing for behaviour change:

-To make it easier for a user to show the desired behaviour
-To make it more difficult for a user to show the undesired behaviour
-To stimulate users to show a particular behaviour
-To make users refrain from showing a particular behaviour

According to Niedderer et al. (2014), there are three categories of designing for behaviour change:

-Approaches that target the individual
-Approaches that target the context
-Approaches that target the middle-ground

The design for circular behaviour approach from Wastling et al. (2018) mixes the research of desired behaviours with a behaviour change model and business models. It also provides clear steps for developing a design for circular behaviour:

Step 1, Specify desired circular behaviour
Step 2, Research context and user with user-centred design research strategies using the COM-B model
Step 3, Develop design interventions with a design tool and business model aspects
Step 4, Prototyping, testing in real life

The same kind of steps are used in research on designing choice architecture intervention by Münscher, Vetter, and Scheuerle (2015). They suggest a framework with interventions for influencing the decision making process by giving three categories. Decision information, decision structure and decision assistance. The steps in their

framework are the following:

Step 1, Define behavioural problem and target behaviour
Step 2, Analyse applicability of choice architecture framework
Step 3, Check for behavioural bottlenecks (defined as: does the cause lie in the psychology of human decision making)
Step 4, Build hypotheses on promising choice architecture interventions

The steps of these different approaches are combined and used in sub question 4.

SQ4: "Which aspects need to be operationalised to conduct an empirical research on the influence of design on behaviour?"

The literature study provided information on what aspects need to be present in a framework to perform an empirical study. The literature review provides many insights regarding circular behaviour, behaviour theories, and design for behaviour practice. When designing for a certain behaviour, first a specific behaviour has to be chosen to design for. The third subquestion provides the answer that a behavioural model should be used when designing for behaviour change. For the development of the framework in this study, the COM-B theory is used because it is an integrated model. It is also stated that a design technique should be used that focuses on behaviour change. For this research, the choice architecture is chosen because it focuses on the decision-making process. All these factors are put into a table that will be adjusted based on the chosen behaviour and the findings of the context and user research. The table is used to inventorize the different aspects related to behavioural categories. The influence of the aspects are shown with colour coding and textual explanation. Green indicates a positive influence, yellow is mixed, red is negative. This general table then is translated to specific behaviours for the emprical research. The general table is presented in table 8.

Methodology

This research aims to describe the relationship between circular behaviour and design and to make recommendations on future design practice. To do so, several stages of research must take place. The first stage is a literature review. As mentioned

COM-B aspect	Design aspect	Choice technique	Influence
Capability physical	Distance	B1,B2	
	Weight	B2,B3	
	Accessibility	B2,B3	
	Height	B1,B2	
	Thresholds	B2,B3	
Capability psychological	Difficulty	A1,B2,B3,C1	
	Access to information	A2	
	Reminders	C1	
	Understanding	A1,A2	
Opportunity physical	Availability of inanimate objects	B1,B3	
	Duration	B2,B3	
	Costs financial	B2,B4	
	Costs social	B2,B4	
	Distance	B1,B2	
Opportunity social	Rules from organisation	A3,B4,C2	
	Norms	A3	
	Culture	A3	
	Participation	A2,C2	
Motivation reflective	Informing	A1,A2,A3	
	Important factors	depends	
	Reminders	C1	
	Rewards	B4	
	Punishment	B4	
Motivation automatic	Cue's	B1	
	Triggers	B1	
	Direct feedback	B4	
	Stable environment	B1	

Table 8: General table with specific combination of COM-B aspects and Choice Architecture techniques (Own creation)

in the problem statement, understanding circular behaviour and how it can be influenced is necessary to research how a design can influence those factors that stimulate circular behaviour. A table is made based on the literature review that will be used to do multiple case studies. The table will act as a lens to view the cases with to inventorize all factors influencing behaviour for the specific cases. The next stage is the empirical study consisting of case studies with document analysis and semi-structured interviews. In the case studies, student complexes will be researched to what extent the design influences specific circular behaviours. First a document analysis will take place in which general information about the building, floor plans, and organisational structure will be studied. Next, semi-structured interviews will be done with inhabitants of the case study projects to gain more insight in the current situation and in what way the students experience the design in relation to circular behaviours. Finally, in the last phase recommendations will be made based on the knowledge gained from the theoretical background and case studies for future design practice.

Empirical research

This phase aims to answer the fifth sub question:

SQ5: "What influence do designs have on the circular behaviours of Reuse/Resell and Recycle Materials of inhabitants in current practice in student housing complexes?"

In this second phase, empirical research is done to find how the inhabitants are influenced by the design. For all cases the general table 8 will be translated to the specific behaviours and then expanded on and adjusted with the gained knowledge from the case studies. Two cases are studied in parallel in the same manner. First a document analysis is done which is then supplemented with semi-structured interviews with residents of the studied cases. The interviews will be analysed in Atlas.Ti with open-coding to allow for new themes to arise. The table is then filled in based on findings on the influence of the design on behavioural factors mapped according to the respective behaviour category of the COM-B model. The findings are then examined and a cross-case analysis is done. The findings of this phase will be used in the final phase for recommendations for future design practice.

It can be concluded that the design of the buildings influenced the interviewees in multiple ways. The analytical framework was successfully employed in the cases for the specific behaviours and provided many insights into different factors influencing different factors that determine behaviour. Some factors were not related to the building, but rather to products, culture, personal preferences or financial. It became clear that for the psychological capability, the design fails to inform the interviewees on the proper practice of the behaviour. The physical opportunity was very positive for Reuse, but not so for Recycle Materials. Nevertheless, most of the interviewees still showed both behaviours to a certain extent. The factors related to the design of the building were the Distance, Availability, Costs, Convenience, Visibility, Accessibility, Duration and Information. These are mentioned as the degree of capability and opportunity which influence motivation according to the COM-B model. It was also found that some interviewees were highly motivated, which overcame a perceived low degree of opportunity. This high motivation caused them to personally increase the degree of physical opportunity for themself. Likewise, a high degree of capability and opportunity could motivate an unmotivated person to show a behaviour as was found in the second case.

Conclusion

A design has an influence on behaviour. When looking at behaviour through the lens of the COM-B model, there are different categories which are all affected by design. A design can make behaviour impossible by having a negative influence on one of the three or more categories. A design can also make a behaviour possible, by changing the categories that are negative into positive. In between the two extremes of possible and impossible there is also the degree of the categories that influence behaviours. Someone could be able to show behaviour, but if it takes too much effort the person refrains from the behaviour. If there is a high degree of capability and opportunity, it can motivate a person to show the behaviour, and likewise a low degree can demotivate.

For a smooth transition to a circular economy, circular behaviours should be defined more and their impacts should be measured. For each of the behaviours the context should be researched to what extent they influence behaviour. If it has a negative or low degree of capability and opportunity it should be changed to stimulate more circular behaviours. One way to approach this is by using the same method of this research. By using the analytical framework to map the different factors that influence behaviour by researching the context and the users. However, it must be noted that behaviour is a complex phenomenon with a multitude of factors that influence it, both conscious and unconscious. It is difficult to map all the different factors for every person. Not all factors are related to a design, there are also beliefs and values that have influence in behaviour.

Discussion

Many theories have been presented in the literature study but these were specific to one type of goal as mentioned by the goal framing theory. The COM-B model provided a clear overview that categorised most of the factors of the different theories in one model, making it easy to use in an empirical research. The other theories would only focus on one type of goal, making it necessary to fill in multiple frameworks or tables per behaviour to get a complete picture. However, behaviour is a very complex subject which has many factors that

influence it. There are factors unrelated to the design that determine the way a person behaves with or around the designed item. The COM-B behavioural model helped to provide a scope to research specific aspects that influence behaviour. The theory helps to determine whether people should be capable and have the opportunity to show the behaviour. If these aspects are positive, the person only needs to be motivated to show the behaviour.

When inventorizing the different aspects that influence behaviour, using the analytical framework, it was difficult to place them in only one category for some aspects. For example the distance can influence all factors, but it is dependent on the person wheter the influence is positive or negative. This shows the personal nature of the findings, which can be generalised, but not to be expected to work for everyone as there are more factors that determine whether a person shows behaviour. Nevertheless, improving the degree of capability and opportunity will make it easier for everyone to show the behaviour which can lead to increased motivation and showing the desired behaviours.

Limitations

The questions of the interviews focus on the rationale behind the behaviours. However, the interviewees could have not provided true data. They might have refrained from saying things they are ashamed of or were not comfortable in sharing. They could also lie and pretend to behave in a certain way. It is also possible that they were not aware of factors that influence them. Therefore the findings are only true if the data that was collected is true. In order to make the interviewees comfortable to speak freely, part of the interview protocol was to stress that there are no right or wrong statements, and that the goal of the interview is to gain insight, not judge.

It was chosen to focus only on factors that influence the COM-B model. Aspects that are not included in this model are factors such as age, sex, and education. Factors that were not taken into account have influence on the behaviour of the interviewees as well. It might be that one of those factors have more influence than the design of the building.

Future research

In this research, only two cases have been studied and few interviews have been done. The analytical framework can be expanded much more. By repeating the empirical study over more cases, more

design aspects, examples, and their influence can be found. Also a way to measure the importance of the factors should be researched. As some aspects can have a greater impact than others. This thesis focused on student housing, but the method can be applied to other functions as well, such as offices, parks, museums or other public places. Not only should the cases be researched as in this thesis, but the findings should also be tested and prototyped in existing and new cases. To do so the behaviours must first be measured in the existing situation and then compared with the results of the new behaviours in the new context. Finally, the feasibility of the interventions has not been studied as it was not in the scope of this research. The costs and benefits of interventions that can be designed based on the findings of the research can still be researched.

TABLE OF CONTENTS

In the Netherlands, in the current transition towards a circular economy, a lot of effort is being made on redesigning products and materials in a way that they become circular (Ministerie van Infrastructuur en Waterstaat, 2021). Also new services are invented which allow for the circular use of products (Rexfelt & Selvefors, 2021). However, there is a missing link. If buildings are made of circular materials but no changes are made in the lay-out, the building can still act as a threshold to its users to show circular behaviour. In a circular society people have to collaborate to ensure that all materials will end up in the right and most sustainable place (Selvefors, Rexfelt, Renström, & Strömberg, 2019). By only focussing on making materials circular so that they can be used in a closed loop, but neglecting the part of what this will actually look like in everyday life, an important part is being left out of the equation. People should be enabled to show circular behaviour from their home, in the office, or in a public place.

If the built environment is designed in a way that it enables and stimulates circular behaviour, it could result in more people participating in circular activities, ultimately smoothing the transition towards a circular economy (Hanemaaijer et al., 2021; Wastling et al., 2018). Currently, in circular architectural design, the focus lies heavily on the material side and not on the social aspect (Salvador, Barros, Luz, Piekarski, & De Francisco, 2020).

Main Question: "What is the relation between design and circular behaviour?"

To stimulate advancements in design for circularity, this research will look into the relationship of circular behaviour with design. First a literature research is done to gather theoretical knowledge based on which a framework is made to perform empirical research. By first defining circular behaviour, then looking into behaviour models, and finally on designing for behaviour change; the framework is made with which case studies and interviews are done to research this relationship in practice.

This thesis produces a framework that can be used to research different behaviours in different contexts. The findings of the empirical research describe the relationship of the design with the specific circular

behaviours of Reuse/Resell and Recycle materials in the studied cases. By performing multiple case studies, best practice advice can be given on what aspects of design should be recommended and which should be avoided. The built environment can be changed based on this research by stimulating people to have a lower environmental impact through their behaviours. Appendix A provides 10 steps that can be followed to replicate the study. The other appendixes serve to smoothen the process of replicating the study.

1.1 Problem Statement

Depleting earth's resources
Earth's resources are becoming more and more depleted as a result of the linear economy. Earth Overshoot Day is the day on which humanity has used just as much resources as the earth can produce in one year, counting from the 1st of january. Mankind has been overshooting the planet for more than 45 years and there is a trend that it will only overshoot even more. In 1977, 'earth overshoot day' was on the 1st of november, which is 61 days short of one year. In 2021, it was on the 29th of july, which is 155 days short of one year. This means that we are currently using more than 1,7 times the resources, effectively draining the resources of the earth (Global Footprint Network, 2021). One way to reverse this trend is to move away from the current linear economy and transition to a circular economy. Below a definition of the circular economy is given by the Ellen MacArthur Foundation, which is a charity that is concerned with accelerating the transition to a circular economy. The Ellen MacArthur Foundation is one of the frontrunners in promoting the transition to a circular economy.

"*A Circular Economy is an economic and industrial system where material loops are closed and slowed and value creation is aimed for at every chain in the system.*"

-Ellen MacArthur Foundation, 2021

Wasting resources
In the Netherlands, around 490 kilos of waste is produced per person per year on average. From this waste, around 60% is being seperated. In 2018, over 8.300 million kilos of waste was collected from

households, which is more than the non recycled waste from construction, industry and agriculture sectors combined. The Netherlands currently has the goal to reduce the amount of rest waste per person from 170 kilo on average to 30 kilo per person by 2025 (Milieu Centraal, 2021a). In current practice, the rest waste gets incinerated. By reducing the amount of rest waste, more resources can be saved and recycled leading to lower environmental impact (Milieu Centraal, 2021b).

New way of consumption requires new way of designing

With a circular economy comes a new way of consumption which requires a new design approach (Selvefors et al., 2019). Products must no longer only focus on the obtainment phase but also on the use and riddance phase. Thought must be given to the behaviour of people that comes with the riddance phase as can be seen in figure 1. The house of the future should be equipped to facilitate circular behaviour.

According to Selvefors et al., (2019), *"circular consumption processes necessitate new activities and decisions and also entail different everyday challenges compared to linear consumption processes. The practicalities and challenges that circularity entails* *may not only make people consider it inconvenient, time consuming, or in other ways undesirable to transfer products from use to use, they can also contribute to disrupting a circular flow altogether. Addressing such aspects through design is thus essential in order to develop new products and services more fit for circular consumption."* (Selvefors et al., 2019, p. 1020).

If people change their behaviour from linear to circular it will be beneficial in the transition towards a circular economy (Hanemaaijer et al., 2021; Wastling et al., 2018). However, current designs and layouts are not yet suitable for a circular economy. They require people to take initiative to act in a circular way. In current practice, when architects design for circularity, they focus only on the building materials and not on the required future circular behaviour (Kanters, 2020; Berg, Voordijk, & Adriaanse, 2019; Wastling et al., 2018). The designs should also enable, stimulate and simplify circular behaviour. For example, if someone wants to separate waste in his household, s/he has to make room for and create or buy several trash cans. The person might refrain from showing circular behaviour because of these kinds of thresholds.

Currently, there is a lack of interest from businesses into the daily life practises in a circular economy.

The product life-cycle as a point of departure

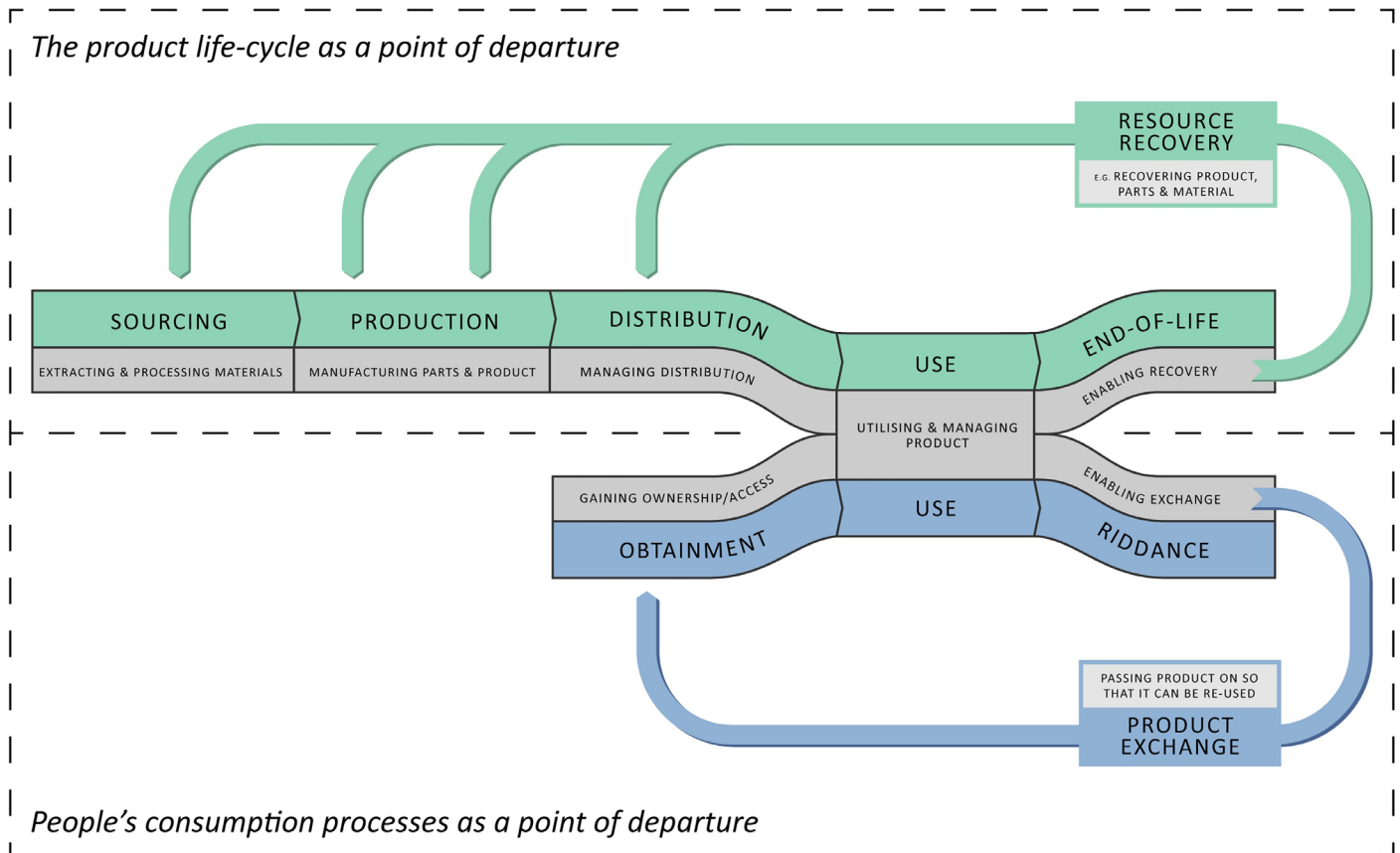People's consumption processes as a point of departure

Figure 1, "Opportunities for circularity can be explored either by taking the generic product life-cycle as a point of departure or by taking people's consumption processes as a point of departure." (Selvefors et al., 2019, p. 1017)

Product circularity from a production and business model point of view	Product circularity from a user point of view
The product life-cycle as a point of departure.	People's consumption processes as a point of departure.
Companies as the nexus of circularity.	People as the nexus of circularity.
Consumption described as *Distribution*, *Use* and *End-of-life*.	Consumption described as *Obtainment*, *Use* and *Riddance*.
Circularity through resource recovery.	Circularity through product exchange.
Companies as providers of products and services fit for circular production.	Companies as providers of products and services that support and fit into circular consumption.
Companies as developers of circular business models.	Companies as exchange agents that can support people's circular consumption.

Table 1: a comparison between the current and the reframed narrative for product circularity (Selvefors et al., 2019, p. 1026)

Businesses should focus on the disposal/riddance phase as well (Selvefors et al., 2019). For example flat-packed furniture should not only be easily assembled, but also easily put back into the box as well for future reuse. Making it easier for users to show circular behaviour. This also raises the question if architects should design a new kind of layout that will aid in the process of the disposal/riddance phase.

When circular products and services are designed from a user perspective, it can reduce the resource throughput and result in "commercially profitable and attractive [products] for people to use in everyday life" (Selvefors et al., 2019, p.1015). In table 1, an overview is given for reframing product circularity from a user perspective.

Current practice, designing for circularity lacks user focus

Current circular projects are mostly experimental pilots that try out some innovative way or construction. Some countries are striving more towards circularity but it is still in its infancy. There are not many circular construction or demolition companies yet, and the current construction industry does not want to bear the risks that come with innovation as there is a huge dependency throughout the industry to make it work (Kanters, 2020). It requires more than one party to decide to do something circular.

In current practice, a project will only be (partially) circular if the developer wants it to be. The main driving force for a construction project to become circular is the brief (Kanters, 2020). An architect might have circular ambitions or dreams but if the developer is not convinced or doesn't want to pay the extra costs that are currently related to circularity, the project simply won't be circular (Dokter, Thuvander, & Rahe, 2021). In the future, when circularity is the norm this will no longer be the case, but current regulations are not yet so,

and current regulations are focused on energy performance. In the Netherlands more policies are coming for circularity, but globally there is not yet a trend for this. So if the architect or designer has circular ambitions, he has the challenge to take on multiple new additional roles (Kanters, 2020). He would have to connect all the dots between the producers and clients, show financial feasibility and make predictions about the future to convince the client and future users to take on the circular materials/principles. Because circularity is still a new field, much innovation has to be done which comes with extra costs that are mainly due to researching, time and low supply (Cirkelstad, 2018). This makes the job for architects to convince the client even more challenging. Some firms have a dedicated CE branch that gives advice to the architects (Kanters, 2020). It is important to take into account that the responsibility for circular design does not lie with the architect, but if he has tools to convince the developer he could do so more easily.

Most of the research on designing for circularity in the built environment focuses on the materials of the buildings. On the amount of virgin materials, renewable materials, recyclability, and waste materials (Kanters, 2020; Berg, Voordijk, & Adriaanse, 2019). In a circular economy, a new kind of infrastructure and changes in housing typology might be necessary to facilitate circular behaviour.

Another way that architects design for circularity is with principles like flexibility, efficiency, and minimalism. In research from Silvia (2020), an example is given of how circularity, prefabrication and modularity can affect the way we live. By prioritising prefabrication and modularity a great reduction in carbon footprint is achieved. Also a new kind of large-scale infrastructure has been designed and by combining separate housing units with communal activities, the building is flexible, fit for disassembly, recycling and future use.
If the developer and the architect agreed on striving for circularity, there is still the user that needs to be

convinced of the circular principles. Without the user, there won't be a successful project. You might have a fully circular building within budget, but if it is not serving the needs of the user, they won't use it. Therefore, it is important to take the behaviour of the user into account when designing circular buildings. However, as mentioned earlier, the focus in circular design currently lies mainly on the material aspect and the circular business models are neglecting social aspects of sustainability (Salvador et al., 2020). Which is understandable as it is the main challenge with the greatest impact to be tackled, but the product has to be used by someone as well and the circular economy entails more than construction only.

The problem therefore is that a standard for designing for circular behaviour in the built environment is missing. There is a knowledge gap on how a design can influence behaviour of the users to be more circular.

To summarise the problem statement:

-Earth's resources are being depleted
-Waste has to be separated more
-Need for transition towards circular economy
-A circular economy challenges and requires new behaviours
-In current design practice, the focus lies on products and materials, not on new behaviours
-There is a knowledge gap on how design can influence behaviour to be more circular in the built environment

1.2 Scope
The purpose of this study is to describe the relationship between design and circular behaviour in housing. As this is a broad concept, the focus of this research will be narrowed down to two specific behaviours in a similar context. To keep the context similar, the sample group that is chosen is students living in student housing complexes. There are multiple reasons for this choice. The main reason is convenience and accessibility to data and interviewees. Other reasons include potential impact, high moving frequency of students, low economic power of students, and finally to be able to gather in depth information on a few cases due to time limitations.
For circular behaviours the choice is made to focus only on reuse/resell and recycle materials as defined by Vermeulen et al. (2018). The literature review

shows potential circular behaviours to choose from. The decision to focus on reuse/resell and recycle materials is made based on the potential impact, national goals to reduce average rest waste per person, the frequency of the behaviour, and physical objects are needed to show the behaviour.

1.3 Research output
This research aims to gain more insight into the relationship between circular behaviour and design. To do so, first an understanding of circular behaviour is necessary. As circular behaviour is a broad concept that is not fully understood, the first output would be a definition and examples of circular behaviour. The next step for this research is to narrow it down to circular behaviour of a specific stakeholder, the student living in a student housing complex. The second output of this research is which factors that influence behaviour can be influenced by design. By looking into different behaviour theories, important factors that determine behaviour can be found, which can be used in categorising interventions. The findings of the literature research questions provide input for an analytical framework that will be used to do case studies and interviews with. This framework is transferable and replicable to study other behaviours in different settings as well. The case studies provide information on the current influence of the studied building's design on the circular behaviour of its residents. Appendix A provides an overview of the 10 steps that are taken to replicate this research.

The final output will be insight into what the relationship is between specific circular behaviours and designs of the studied cases. Recommendations are made for when designing for the specific behaviours in the studied cases, and in general.

1.4 Research questions
Main Question: "What is the relation between design and circular behaviour?"

In this main research question, circular behaviour, is referred to as the behaviours in daily life that take place at home that allow circularity. As circularity is a rather broad concept, a definition for these behaviours is necessary. One example of circular behaviour is the correct recycling of materials but for a more extensive analysis of what is defined as circular behaviour, the first sub question contends a literature review.

15

For the topic of design it is chosen to keep it fairly broad as many aspects of a design can have an effect on the behaviour. Not only architectural design, but also organisational design or social design can be part of this equation.

For this qualitative research a small sample group is researched in-depth to provide more confidence in findings (Miles & Hubberman, 1994). The sample group of students living in student complexes is chosen as the first exploratory group for this replicable research as explained in the scope.

Several sub research questions are created in order to answer the primary research question. The sub questions are listed below, along with a brief description of the topics they will cover.

Sub Question 1: "What is circular behaviour?"
Currently, in the field of circularity there are many different definitions. Because there is not yet a consensus on a single definition, partly because the different perspectives require different definitions, it is an important first step for this research to define what behaviours are deemed as circular in the context of housing. To do so, literature research will be done to find out what the current standpoints are on circular behaviour. A definition will be chosen that is used in this research.

Sub Question 2: "What factors influence behaviour?"
In order to understand the relationship between behaviour and design, a thorough understanding of what factors influence behaviour is necessary. By first understanding why and how people decide on their behaviours, the most important factors can be filtered out. The answers to this question can help in giving valuable information on key points to look for in case studies, and important factors to ask about in interviews. To answer this question, scientific literature on psychology will be studied and the most prominent models will be explained. This sub question helps to decide on a final model to use in the case studies.

Sub Question 3: "In what way does design influence behaviour?"
After having an understanding of important factors that influence behaviour, research will be done on how design influences behaviour. By looking into the general practice of designing for behaviour change, an overview of different practices can be found. From these practices, a few models will be looked into in further detail to gain more understanding of how these models work. And finally a model to use in this research is chosen.

Sub Question 4: "Which aspects need to be operationalised to conduct an empirical research on the influence of design on behaviour?"

Based on the findings in literature from the first three sub questions, a framework is created with which the influence of design on behaviour can be researched. The found aspects will be operationalised to make an analytical framework that is ready to use for empirical studies.

Sub question 5: "What influence do designs have on the circular behaviours of Reuse/Resell and Recycle Materials of inhabitants in current practice in student housing complexes?"

The framework is used to inventorize different design aspects according to their COM-B subcategories. First the context is researched and next interviews are done to validate the findings and to map new factors that influence their behaviour.

Sub question 6: "Based on the lessons learned from the theoretical background and empirical research, which recommendations can be made for the future design of student housing complexes or designs in general to stimulate circular behaviour?"

The answers to all previous questions result in a lot of qualitative data on the relationship between circular behaviour and design. This data can be used to provide recommendations on what the future of design of student housing complexes should look like to synergize with the transition towards a circular economy.

1.5 Societal and scientific relevance

Societal relevance:
The transition to a circular economy is difficult, there are many challenges that are being addressed, such as how to build with circular materials. However, there is a knowledge gap on how to build for circular behaviour. Designers are already being overwhelmed with the challenges that focus on materials that come with circularity. Increasingly more and more tools and help are available for tackling those challenges. However, the challenge

for designing for circular behaviour in housing is not yet addressed. Society as a whole would benefit if it would be made easier for them to exercise circular behaviour. This thesis aims to describe how circular behaviour is affected by the built environment. If people show more circular behaviour, it will become easier for companies to have feasible circular business models (Salvador et al., 2020). The companies will gain access to materials that would have been lost to a landfill or incinerator and can more easily provide services that will stimulate more circular behaviour.

With the two cases in this study combined, around 400 students living there could be stimulated to reuse more and recycle materials, potentially saving 56.000kg or more waste per year from incineration, allowing it to be recycled (Milieu Centraal 2021a). There are many more student complexes in the Netherlands, and this research can be replicated for other building typologies as well, making the impact even higher. When applying it to just forty cases of similar size, the impact will reach over one million kilograms of waste per year that could be saved from incineration.

Scientific relevance:

In research from Wastling et al. (2018), it is stated that the role of the user of a product is very important, but that their part in the circular economy has not yet been clearly described. In the first part of this thesis, the part of an inhabitant of student housing as a user in a circular economy is described by defining their circular behaviour. By defining what kind of behaviours should be expected from those inhabitants, this gap is bridged.

In circular design, not only a focus on product circularity is necessary. It is also necessary to answer the question 'How can the design of products and systems encourage or enable users to behave in [a circular] way?' (Wastling et al., 2018, p. 4). Selvefors et al., (2019) add to this that it is essential to address aspects such as convenience related to everyday activities in a circular consumption process.

This thesis aims to describe the relationship between circular behaviour and design and looks into the psychological and contextual factors that influence circular behaviours. To do so a framework is created that can be used for other building typologies with different target groups and different behaviours in future research. This framework can aid architects and other designers to more easily design for circular behaviour.

The first part of this research is a literature study to answer the first four subquestions:

SQ1: "What is circular behaviour?"
SQ2: "What factors influence behaviour?"
SQ3: "How does design influence behaviour?".
SQ4: "Which aspects need to be operationalised to conduct an empirical research on the influence of design on behaviour?"

To answer these questions a combination of multiple domains is required. Therefore a definition of circular behaviour will be studied as well as the current literature on behaviour change and decision making, and third, a summary of ways of designing that focus on influencing behaviour will be given. Understanding of these topics can provide answers to what the relationship is between circular behaviour and design and help design a framework to do case studies and interviews to research what this relation between design and behaviour is like in practice. The summarized answers to the questions are presented in the conclusions chapter.

SQ1: What is circular behaviour in the built environment?

In order to answer this question, first the current practice of measuring circularity in the built environment is researched. Next two specific models are explained which focus more on the consumer and required behaviours for circular business models. This question aims to provide an overview of circular behaviours to choose from.

Measuring circularity

Currently, there are many different ways to measure circularity. However, there is no consensus about which method is the best one (Heesbeen, Zabek & Hilderbrand, 2021; Sreekumar, 2019). This results in problems along the design chain as it is not really clear what the most important aspects are to reach for circularity. One of the causes is that there are many different definitions of a circular economy and every branch has their own way of measuring their level of circularity. With circular practices also comes a lot of data and it is difficult to manage this data and to weigh and normalise the data (Rahla, Bragança, & Mateus, 2019).

Being able to measure circularity is beneficial for a smooth transition to a circular economy (Heesbeen, Zabek & Hilderbrand, 2021). Currently most measurements focus on materials, possibility to disassemble, amount of virgin materials, carbon footprint, product lifetime, flexibility, and amount of waste generated (Attia & Al-Obaidy, 2021; Cottafava & Ritzen, 2021; Heisel & Rau-Oberhuber, 2020). There are more holistic methods of measuring that also incorporate sustainability and climate, but the methods disregard the behaviour of the users. This might be because it is difficult to measure the behaviour of users. According to Attia and Al-Obaidy (2021) there are several approaches that have been proposed to develop evaluation criterea for circularity. "*Ranging from sustainability rating systems (e.g., BREEAM and LEED), life cycle analysis methods, the Cradle to Cradle approach, Circular Building Service Companies (e.g., Oaplis and Werflink), research projects (e.g., BAMB, Facades leasing, FCRBE) and the European Waste Framework Directive and Circular Economy Action Plan.*" (Attia & Al-Obaidy, 2021, p. 1). Currently, there is not yet a European standard method for measuring circularity in the built environment (Heesbeen, Zabek & Hilderbrand, 2021).
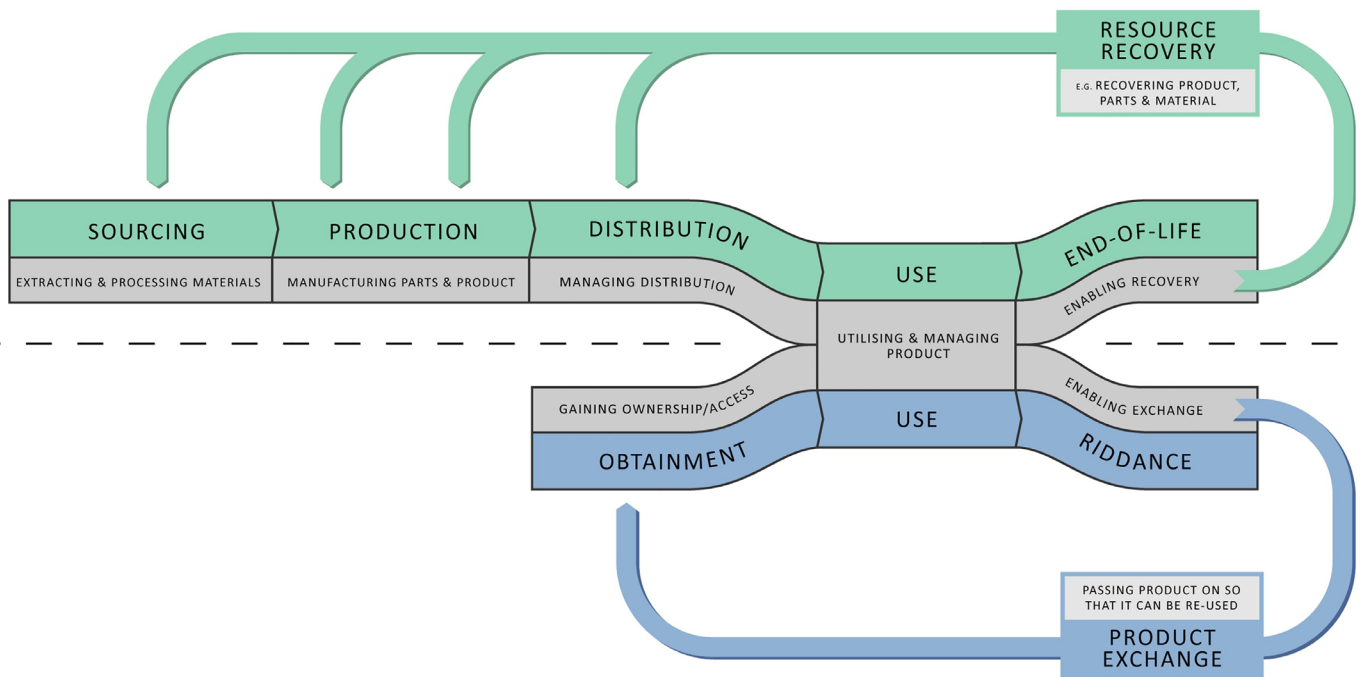
Circular business model desired behaviours

In research from Wastling et al. (2018) on designing for circular behaviour, the desired circular behaviours for circular business models are given. They divided the behaviours into a use phase and end of use phase. And into a user ownership and provider ownership orientation. In figure 2, the results of their case studies and expert interviews are shown.

PHASE:	USE	END OF USE
User ownership (product orientated)	Establishing relationship	Prolong replacement
	Product care	Return product
	Repair	Sell (via third party)
	Engage with product life extension services	Enable reuse
	Product attachment/ownership	Correct disposal/ recycling
Provider Ownership (use/performance orientated)	Adhere to contractual obligations	
	Product care	Fast circulation of goods
	Engage with product life extension services	Reducing operating costs
	Provide information	
	Avoid Product misuse	
	Avoid Damaging behaviours	

Figure 2: Model of Circular Behaviour: an outline of desired behaviours for circular business models (Wastling et al., 2018, p. 9)

RESOURCE
RECOVERY

E.G. RECOVERING PRODUCT,
PARTS & MATERIAL

SOURCING | PRODUCTION | DISTRIBUTION | USE | END-OF-LIFE

EXTRACTING & PROCESSING MATERIALS | MANUFACTURING PARTS & PRODUCT | MANAGING DISTRIBUTION | | ENABLING RECOVERY

UTILISING & MANAGING PRODUCT

GAINING OWNERSHIP/ACCESS | USE | ENABLING EXCHANGE

OBTAINMENT | | RIDDANCE

PASSING PRODUCT ON SO
THAT IT CAN BE RE-USED

PRODUCT
EXCHANGE

People's consumption processes as a point of departure

Figure 1, "Opportunities for circularity can be explored either by taking the generic product life-cycle as a point of departure or by taking people's consumption processes as a point of departure." (Selvefors et al., 2019, p. 1017)

Circular consumption behaviour

With a circular economy comes a new way of consumption which requires a new design approach. Products must no longer only focus on the obtainment phase but also on the use and riddance phase (Selvefors et al. 2019). Thought must be given about the behaviour of people that comes with the riddance phase, it must be made easy for people to do so, because any form of inconvenience can disrupt a circular flow (Selvefors et al., 2019). The house of the future should be equipped to facilitate circular behaviour. Ultimately, the consumer's behaviour determines whether the product is circular or not (Wastling et al., 2018). When the user's behaviour results into a circular life cycle of the product, it is considered to be circular behaviour.

Circular Behaviour

For measuring circular behaviour, the 10R model provides actions that are circular and ranks them to level of circularity. So by keeping the 10R's into account, it is possible to measure whether circular activities are taking place or not. The 10R model shows different kinds of activities ordered to level of circularity. However, according to Vermeulen, et al. (2018), there is no conformity on the R-ladders because there are different R-models circulating

in practice. In order to choose a model without missing out on an important R-aspect, Vermeulen et al. (2018) provide a final 10R model. The model can be seen in table 2. Some organisations and studies refer to only 3 R's or 4 R's and they often use different R's. In order to use the right terms for the different R's, it is chosen to use the definitions provided by Vermeulen et al. (2018). According to Vermeulen, et al. (2018) at the time of writing they could find 38 different R's in the circularity literature and practice. They were able to categorise them and narrow them down to 10 R's which could be seen as a final version of 10R's. It is this R model that will be used to define circular behaviour for residents.

The 38R's mentioned by Vermeulen et al. (2018), in alphabetical order are:

Re-assembly, re-capture, reconditioning, recollect, recover, recreate, rectify, recycle, redesign, redistribute, reduce, re-envision, refit, refurbish, refuse, remarket, re-manufacture, renovate, repair, replacement, reprocess, reproduce, repurpose, resale, resell, re-service, restoration, resynthesize, rethink, retrieve, retrofit, retrograde, return, reuse, reutilise, revenue, reverse and revitalise.

Table 2: Most commonly used descriptions of value retention options and words to better be avoided (Vermeulen et al., 2018, p. 2)

2 distinct product life cycles: Value retention options R0 – R9:	Life Cycle 1: Product Produce and Use / Life Cycle — consumers	Life Cycle 1: Product Produce and Use / Life Cycle — producers/retailers	Life cycle 2: Product Concept and Design / Life Cycle — designers	unspecified general word use (to be further avoided)
Short loops: R0-3				
Refuse: R0	- choice to buy less, or use less; - reject packaging waste and shopping bags	n.a.	- refuse the use of specific hazardous materials or any virgin material; - design production processes to avoid waste	
Reduce: R1	- using purchased products less frequently; - use them with more care and longer.	n.a.	- as explicit steps in product design: - using less material per unit of production; - or 'dematerialization'	*'eliminating waste, not dispose anymore' 'as for all user steps'*
Resell/Re-use: R2	- buying second hand, or finding a buyer for a product that was not or hardly in use, possibly after some cleaning or minor adaptations restoration; - use online consumer-to-consumer auctions for used products	- 'direct re-use' as economic activity via collectors and retailers, possibly with quality inspections, cleaning and small repairs; (commercial and non-commercial); - 'direct re-use' of unsold returns or products with damaged packaging; - multiple re-uses of (transport) packaging	- 're-use in fabrication' - apply recycled materials	
Repair: R3	- by the consumer in their vicinity, or at their location, or through a repair company; - or at a 'repair café'	- send recollected products to their one's own repair centers, to manufacturer-controlled, or to third party repair centers; - distinguish 'planned repair' as part of a longer lasting maintenance plan from 'ad-hoc' repairs	- enable easy repairing	*confused with 'refurbishment'*
Medium Long Loops: R4-6				
Refurbish: R4	n.a.	- overall structure of large multi-component product remains intact, while many components are replaced or repaired, resulting in an overall 'upgrade' of quality of product - Examples: buildings, airplanes, trains, mining shovels		
Remanufacture: R5	n.a.	- full structure of a multi-component product is disassembled, checked, cleaned and when necessary replaced or repaired in an industrial process, recycled parts may be used - expected retained quality more tempered: 'up to original state, like new'		*some also refer to this as 'reconditioning', 'reprocessing' or 'restoration': better avoid*
Repurpose: R6	n.a.		- reusing discarded goods or components adapted for another function:	*some use: 'rethink' or 'fashion upgrading': better avoid*
Long Loops R7-9				
Recycle Materials: R7	- give back as separate waste streams	- processing of mixed streams of post-consumer products or post-producer waste streams using expensive technological equipment, including shredding, melting and other processes to capture (nearly) pure materials;	- apply recycled materials	*'recycle' is frequently and confusingly use to cover all alternatives: better avoid*
Recover (energy): R8	n.a.	capturing energy embodied in waste, linking it to incineration in combination with producing energy, distilled water or use of biomass	n.a.	*'recover' often used as equivalent for general recycling: better avoid*
Re-mine (R9)	n.a.	- retrieval of materials after the landfilling phase: - 'cannibalization'; - hi-tech landfill mining or urban mining	- apply recycled materials	

20

The final 10 R's in order of level of circularity are: Refuse, Reduce, Resell/Re-use, Repair, Refurbish, Remanufacture, Repurpose, Recycle materials, Recover (energy), Re-mine.

Using the different R's, it is possible to filter them down to actions that can be done by inhabitants. In the model of Vermeulen et al. (2018), differences in short, medium and long loops are made. Also on the different stakeholders, consumers, producers and designers. When focusing on the consumers, it can be found which behaviours could be done by inhabitants. According to table 2, consumers can do the following R's: Refuse, Reduce, Resell/Reuse, Repair and Recycle materials. R0-R3 are all in the short loop cycle, only R7 is in the long cycle. In more detail the actions suiting those R's can be seen in table 3.

Type of behaviour	Example bevaviour
R0 Refuse	-choice to buy less, or use less; -reject packaging waste and shopping bags
R1 Reduce	-using purchased products less frequently; - use them with more care and longer.
R2 Resell/re-use	-buying second hand, or finding a buyer for a product that was not or hardly in use, possibly after some cleaning or minor adaptations restoration; -use online consumer-to-consumer auctions for used products
R3 Repair	-by the consumer in their vicinity, or at their location, or through a repair company; -or at a 'repair café'
R7 Recycle Materials	-give back as separate waste streams

Table 3: Excerpt from table 2 (Vermeulen et al., 2018)

The consumer behaviour concepts of Refuse, Reduce, Resell/Re-use, Repair, and Recycle materials are also represented in figure 2 which displays the desired behaviours for circular business models.

Based on the literature study, the following definitions for circular behaviour are defined:

A short definition of circular behaviour is: Value retaining behaviour that leads to closing and or slowing circularity loops.

A longer definition that focuses on inhabitants is: Value retaining behaviour that leads to closing and or slowing loops such as Refuse, Reduce, Resell/Reuse, Repair, Recycle materials and other behaviours that help circular business models function.

SQ2: What factors influence behaviour?

In this chapter the second sub question of the literature research will be answered. In order to understand the relationship between behaviour and design, a thorough understanding of what factors influence behaviour is necessary. By first understanding why and how people decide on their behaviours, the most important factors can be filtered out. The answers to this question can help in giving valuable information on key points to look for in the empirical phase, and important factors to ask about in interviews. To answer this question, scientific literature on psychology will be studied and the most prominent models will be explained. This sub question helps to decide on a final model to use in the case studies.

Environmental psychology

The current consumption model, which is linear, brings about a certain set of behaviours. Considering behaviour change from linear to circular behaviour is beneficial for transitioning to a circular economy (Hanemaaijer et al., 2021; Wastling et al., 2018), the field of environmental psychology can provide insight into factors that influence people to show pro-environmental behaviour. From these factors, factors that can be influenced by design can be filtered out. The findings of environmental psychology are translatable to circular behaviour because circular behaviour is pro-environmental. In figure 3 an overview of the current research on environmental psychology is given.

Environmental psychology contends many theories on behaviour (Steg & Vlek, 2009). There are multiple theories that address specific parts of behaviour. There are individual and contextual factors. According to Steg and de Groot (2019), one of the challenges for future research in environmental

Factors that influence pro-environmental behaviour

Individual:

Goal Framing Theory

Hedonic | Gain or maintain | Normative

Affect Theory | Theory of Planned Behaviour | Value Belief Norm Theory

Norm Activation Model

Habits | Values

Contextual:

Availability | Quality | Supply

Pricing | Physical infrastructure | Technical facilities
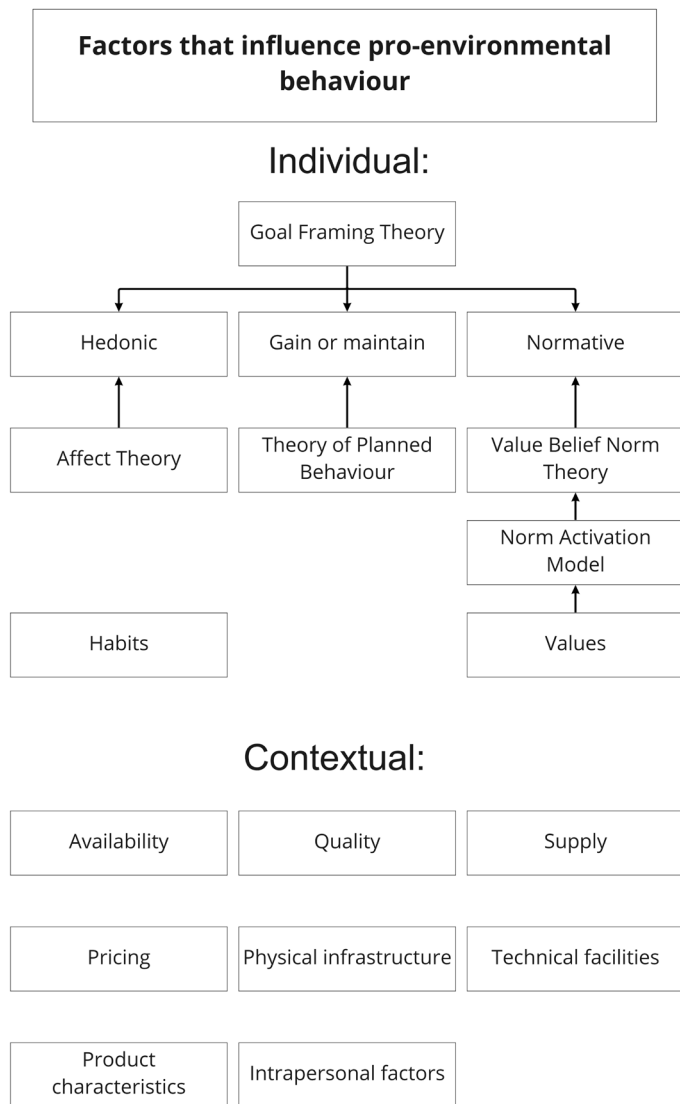
Product characteristics | Intrapersonal factors

Figure 3: Overview of theories and contextual factors that influence pro-environmental behaviour based on Steg & Vlek (2009).

psychology is the integration of these two domains. The overarching theory is goal framing theory. It states that: "Goals frame the way people process information and act upon it. When a goal is activated, it influences what a person thinks of at the moment, what information he is sensitive to and how he will act." (Steg & Vlek, 2009, p.311-312). Goal framing theory holds three general goal frames: hedonic, gain and normative. Hedonic goals are striving for immediate pleasure. Gain goals are aimed at improving or maintaining one's position. Normative goals are goals that are perceived as desirable by society. Affect theories focus on hedonic goals, the theory of planned behaviour on gain goals, norm activation model (NAM), value based norms (VBN), values and environmental concerns focus on normative goals. There are also habits which form a category on their own as they function automatically and work according to a cue-action-reward system (Steg & Vlek, 2009).

The goal framing theory is an integrated theory, the other theories focus on one or more of these categories as can be seen in figure 3. From the three goals, normative goals will provide the most stable behaviour. The hedonic and gain goal related behaviours will only last as long as there are perceived pleasures or gains (Steg & de Groot, 2019).

The normative goals can be explained through NAM, VBN, values and environmental concern (Steg & de Groot, 2019). In figure 4 a schematic representation of the VBN theory is shown. VBN is an extended version of NAM. It expands on a chain of thoughts that need to happen to show pro-environmental behaviour. A person's values influence their beliefs, which in turn influences their behaviour. Only if a person has awareness of a problem, he can determine whether it is his responsibility to solve it. And when he feels responsible, he also has to feel capable of helping the problem with his own actions and the final step is to actually take that action.

Based on personal values and his ecological worldview, a person becomes aware and feels responsibility or not. This can lead to pro-environmental behaviours such as activism, non-activist behaviour in the public sphere, private-sphere behaviours and organisational behaviours. This research focuses on private-sphere behaviours which are for example "the purchase, use, and disposal of products with environmental impact" (Steg & de Groot, 2019).

The theory of planned behaviour focuses mostly on hedonic goals (Steg & Vlek, 2009). It states that people have an attitude, subjective norm and perceived behavioural control and they lead to an intention which in turn can lead to behaviour. Perceived behavioural control is defined as "the perceived ease or difficulty with which the individual will be able to perform or carry out the behaviour, and is very similar to notions of self-efficacy" (Niedderer et al., 2014, p. 26).

The perceived behavioural control can also immediately lead to behaviour. The subjective norm is the social benefits and costs. By influencing people's attitude their intention might change leading to new behaviours. But they will only show that behaviour if they feel like they are capable of showing that behaviour. People's intentions are also influenced by the subjective norm, which
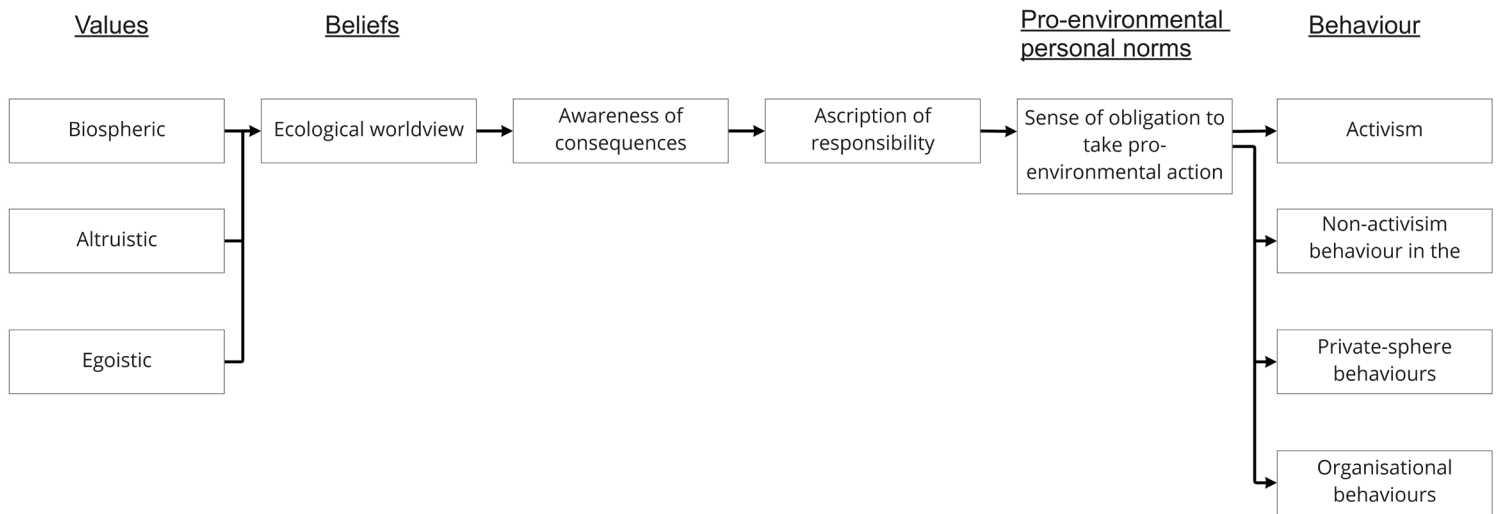
Figure 4: A schematic representation of the VBN theory of environmentalism (Steg & de Groot, 2019, p. 223)

determines whether their actions will make them more accepted in the group or not (Steg & de Groot, 2019).

A limitation of these theories is that they focus only on individual factors and not on contextual factors (Steg & Vlek, 2009).

Contextual factors are the availability, quality, supply, price, physical infrastructure, intrapersonal factors, technical facilities and other product characteristics. It could be that individual factors are actually pro-environmental, but the context is not. Resulting in refraining from pro-environmental behaviour (Steg & Vlek, 2009).

Habits

The previous theories focus on intentional and concious behaviour. But a large part of daily behaviour is automatic (Wood & Rünger, 2016). Therefore understanding habits is necessary for this research. Knowing how they function, it is possible to determine what aspects of design can influence habitual behaviour.

According to Steg and de Groot (2019), habits are behaviour that are dependent on four factors: frequency, stability, success and automaticity. Behaviours that happen daily or weekly in stable contexts with a goal that is achieved through the automated behaviour. When a behaviour is done for the first time, intention is likely to be a strong predictor. The more frequent behaviour is shown, the intention is no longer a predictor of the behaviour but past behaviour is.

A key component of habitual behaviour is a stable context. A consistent environment provides consistent cues which can result in habitual responses. A change of environment helps to disrupt habitual behaviour and allows for new habits to form (Wood & Rünger, 2016).

When people have strong habits, the habits can overpower their intentions and personal norms. This shows why habits are an important factor to take into account, as people don't always act rationally. A strong habit causes people to have a lower level of interest in information about alternative behaviours. Not only do they take into account fewer pieces of information, but they also ignore certain information in the decision-making process. Therefore, just providing information to break habits is not enough (Wood & Rünger, 2016).

There are many different kinds of cue's that can trigger habitual behaviour. There are internal and external cues. The internal cues are ones that originate from a thought, external cues originate from the external environment. The cues can change through naturally occuring life transitions, such as when people switch jobs or move house. This is in line with the stated fact that a change of context will disrupt habitual behaviour. In these new environments, new habits will form (Wood & Rünger, 2016).

COM-B model:

According to West and Michie (2020), the COM-B model of behaviour can be used to research what aspects of behaviour have to change in order for a behaviour change intervention to have effect. The model consists of three main categories that all must be positive for a behaviour to happen.
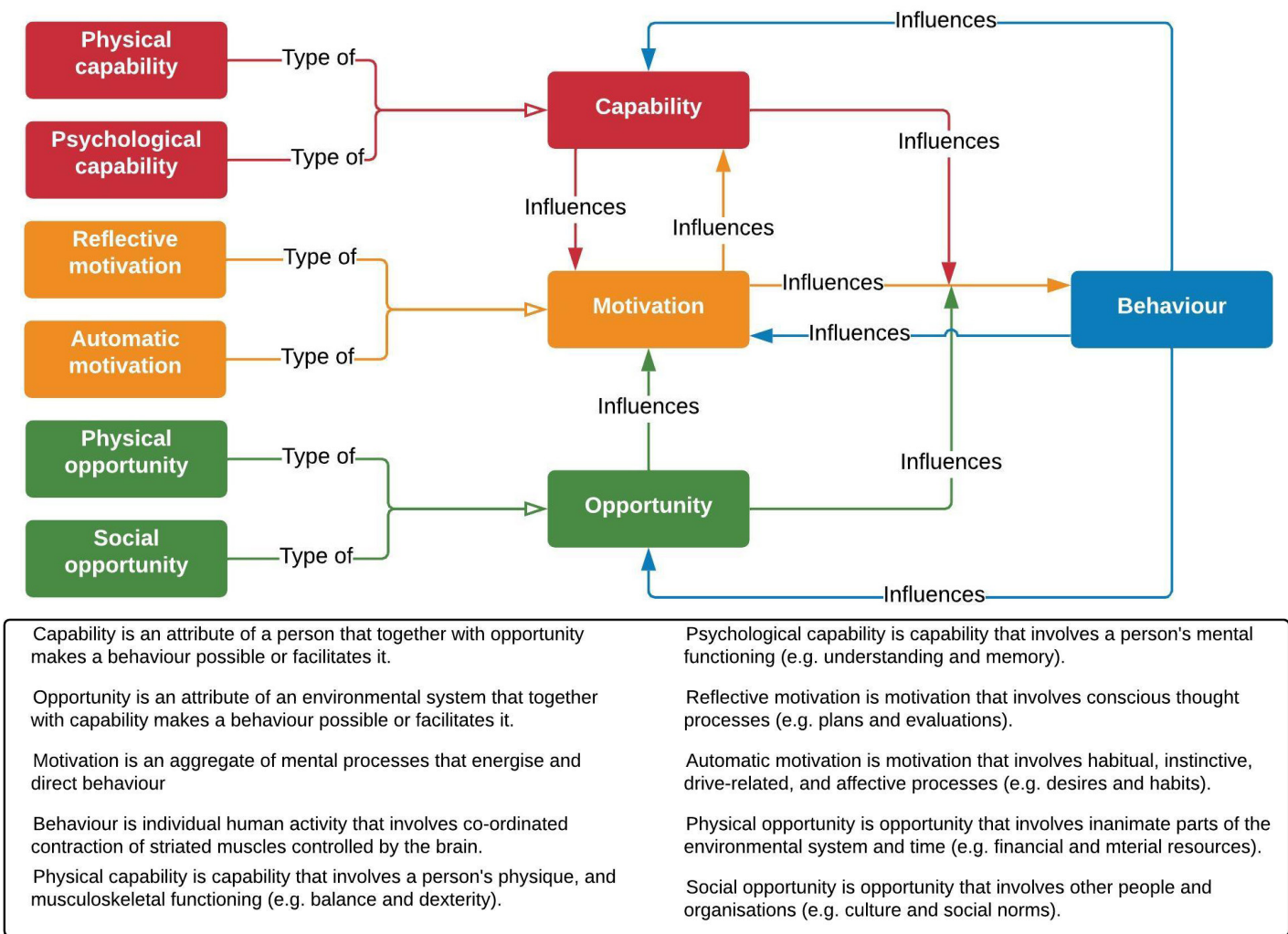
23

Figure 5: The COM-B model of behaviour and the relationship between concepts and their definitions (West & Michie, 2020, p. 2).

The COM-B is an acronym for the three factors: capability, opportunity and motivation. The B stands for behaviour.

The model has been developed with the goal of helping to design effective behaviour change interventions. The theory contends that a behaviour will only be shown if the three factors are in the right condition, they are compared to gates that need to be open. If the gates are open, the behaviour is shown. The person has the capability and opportunity to show the behaviour and is more motivated to show the behaviour over other behaviours. The three main categories can be divided into two more subcategories per category. The relation between concepts and definitions of each factor are given are also shown in figure 5. There is the physical capability, which is about a person's physical physique, for example strength or balance. The psychological capability involves mental functioning such as understanding and memory. Reflective motivation involves conscious thought processes such as plans and evaluations. Automatic motivation are habitual, instinctive and affective processes such as desires and habits. Physical opportunity regards availability of physical objects, money and time. For example the availability of a bus stop or distance to it. Social opportunity involves other people and organisations such as culture and social norms. Using these factors it is possible to map what factor(s) has to change to enable specific behaviours (West & Michie, 2020).

According to West and Michie (2020), there are four important aspects from the COM-B theory. Firstly, the capability and opportunity factors act as gates that need to be open for the behaviour to show. A person might be motivated but not have the capability or opportunity to show the behaviour, resulting in not showing the behaviour.

Second, the degree of capability and opportunity influence motivation. This is influenced by how capable we think we are, or how conducive the environment is to show the behaviour. The higher the capability and opportunity, the more motivated we are to show the behaviour. The opposite is also true, the more difficult the lower the motivation.

Third, the acted out behaviour provides feedback to the COM-B factors. This can be positive or negative feedback. When eating for example, after a while the motivation goes away as you are full. Or when learning a skill, the more you show the behaviour the more you increase your capability, which might then increase your motivation to practise more, showing more of the behaviour.

Finally the fourth aspect, behaviour can be seen as a competition between alternative behaviours.

The COM-B model is an integrated framework from many theories, and most of the theories found from environmental psychology fit in this framework as well. The COM-B model makes a clear overview of different factors that can be influenced to influence behaviour. Making it clearer and easier to research.

SQ3: In what way does design influence behaviour?

In this chapter research will be done on how design can influence behaviour. By looking into the general practice of designing for behaviour change (DfBC), an overview of different practices can be found. From these practices, a few models will be looked into in further detail to gain more understanding of how these models work. Intervention strategies for pro-environmental behaviour from environmental psychology will also be presented. This helps to finally choose a model to use in the empirical phase of this research.

Design for Behaviour Change (DfBC)

In a literature review research on DfBC from Niedderer et al. (2014), there are four main approaches to designing for behaviour change:

-To make it easier for a user to show the desired behaviour
-To make it more difficult for a user to show the undesired behaviour
-To stimulate users to show a particular behaviour
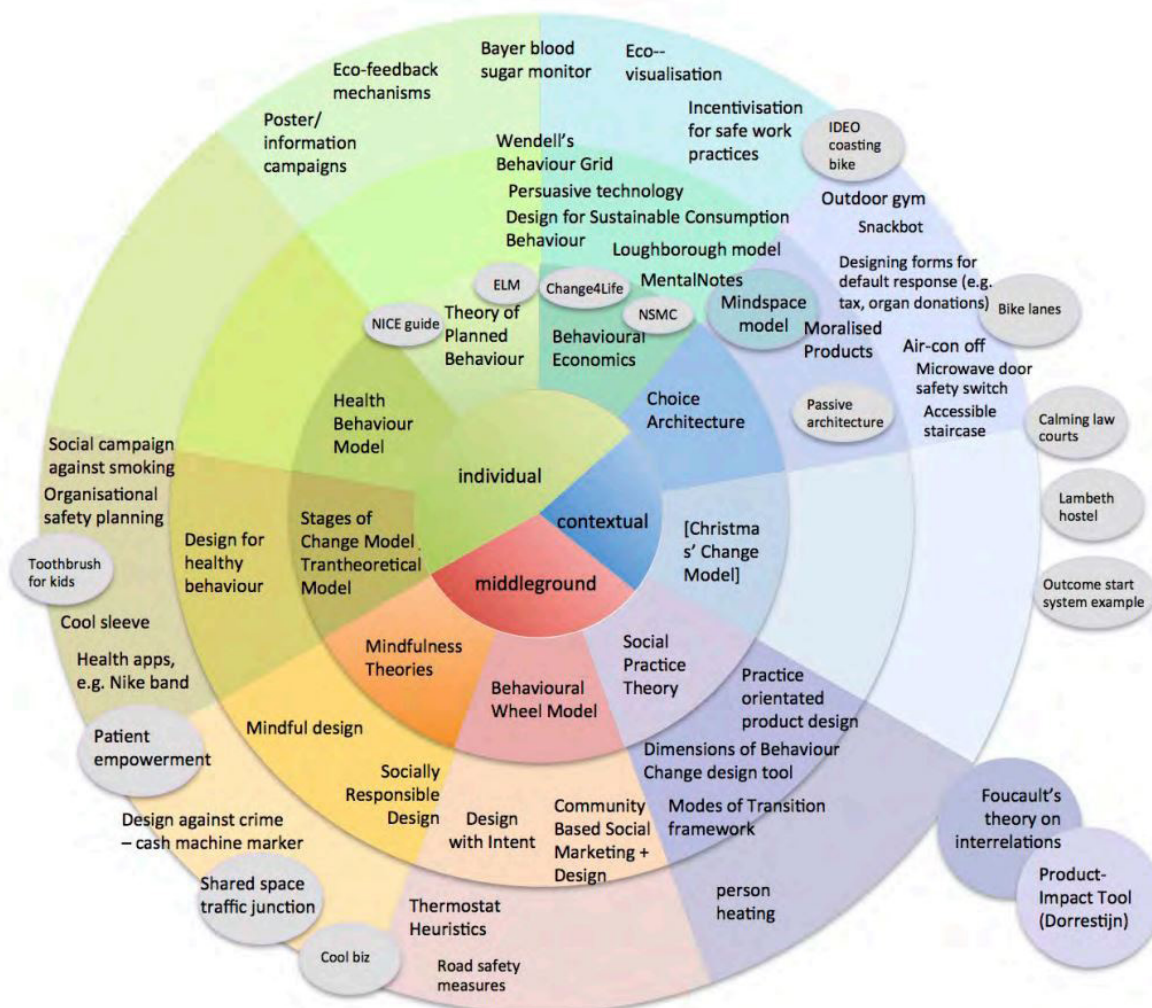-To make users refrain from showing a particular behaviour

Figure 6: Overview of Design for behaviour change with examples (Niedderer et al., 2014).

According to Niedderer et al. (2014), there are three categories of designing for behaviour change:

-Approaches that target the individual
-Approaches that target the context
-Approaches that target the middle-ground

In figure 6 these different approaches are shown in the middle of the figure. The second layer shows the different models of human behaviour and behaviour change that are related to the approaches. The third layer shows design for behaviour change models and the final layer shows real world examples that are designed based on the DfBC.

Figure 6 shows that there are many different models of behaviour change and that there are many ways to approach behaviour change through design. However, not all models are related to the design of a building, but due to the conceptual nature of the different models, some of them can be translated to other areas such as architectural design. It must also be noted that not all of the existing models are present in this figure. In essence, design for behaviour change models aim to give a general understanding of how design can be used to influence behaviour (Niedderer et al., 2014).
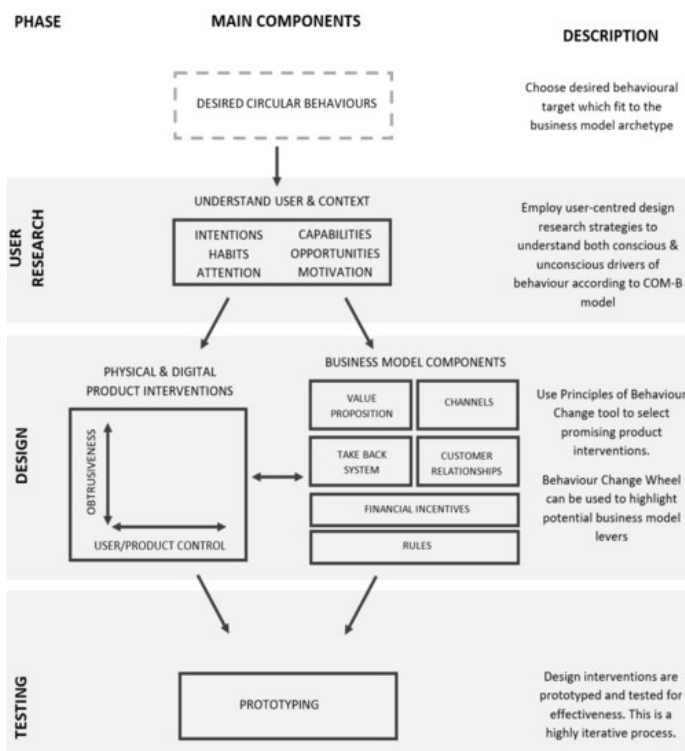

Figure 7: Outline of key components of Design for Circular Behaviour (DfCB) Process (Wastling et al., 2018, p. 12).

Design for Circular Behaviour

A framework has been created to design for circular behaviour by Wastling et al. (2018). This framework provides information on how to design for a desired behaviour. Important to note is that it is originally intended for designing products, not buildings. According to the model of Wastling et al. (2018), designing for Circular Behaviour entails the following phases as can be seen in figure 7:

-Deciding on desired behaviours
-Context & User research phase
-Design phase
-Testing phase

In the first phase, the desired behavioural targets have to be chosen. Only then is it possible to research what influences the user and the context for that desired behaviour. In the model of Wastling et al. (2018), the behavioural model of COM-B is used, which is a simplified version of the Behavioural Wheel model, to research the user and context. It focuses on the capabilities, opportunities, and motivation of the users in relation to the context. In the next phase, the product is designed. Important in the design is the level of user or product control and its level of obtrusiveness. Also its relation to the business model is taken into consideration. Finally a testing phase is done to improve on the design (Wastling et al., 2018).

Choice architecture

Choice architecture is about how a design has influence on the way you use it or how you behave because of it without taking away the freedom of choice or providing financial incentives (Thaler, Sunstein, & Balz, 2010). Choice architecture has been successfully implemented in multiple domains and settings such as transport, financial decision making, public health, sustainability, schools, hospitals and more. Choice architecture provides techniques that focus on influencing the decision making process. (Kraak, Englund, Misyak, & Serrano, 2017; Szaszi, Palinkas, Palfi, Szollosi, & Aczel, 2017).

"*Choice architecture techniques seem to promise generally applicable and easily implementable solutions to societal problems.*" (Szaszi et al., 2017, p. 355). An example of its simplicity and effectiveness in the domain of sustainable energy is the choice to opt-in or opt out of more expensive renewable energy. When asking people to opt-in only 7% did

so. When asked to opt-out 70% did not opt out (Szaszi et al., 2017). A slight difference in choice has the potential to generate a ten times bigger outcome.

In their research, Münscher et al. (2015) provide a framework for the development and transfer of successful choice architecture interventions. The three main categories suggested for choice architecture are (A) decision information, (B) decision structure and (C) decision assistance. Each category has its own techniques to be applied which are explained in the research as well. Table 4 provides an overview of all techniques.

Category	Technique
A. Decision information	A 1 Translate information *Includes*: *reframe, simplify* A 2 Make information visible *Includes*: *make own behavior visible (feedback), make external information visible* A 3 Provide social reference point *Includes*: *refer to descriptive norm, refer to opinion leader*
B. Decision structure	B 1 Change choice defaults *Includes*: *set no-action default, use prompted choice* B 2 Change option-related effort *Includes*: *increase/decrease physical/financial effort* B 3 Change range or composition of options *Includes*: *change categories, change grouping of options* B 4 Change option consequences *Includes*: *connect decision to benefit/cost, change social consequences of the decision*
C. Decision assistance	C 1 Provide reminders C 2 Facilitate commitment *Includes*: *support self-commitment/public commitment*

Table 4: Choice architecture categories and techniques (Münscher, et al., 2015, p. 514)

Münscher et al. (2015) suggest a development process for choice architecture interventions with a simpler version of "the behaviour change wheel" model by Michie et al. (2011):

Step 1: Define behavioural problem and target behaviour
Step 2: Analyse applicability of choice architecture framework
Step 3: Check for behavioural bottlenecks (defined as: does the cause lie in the psychology of human decision making)
Step 4: Build hypotheses on promising choice architecture interventions

Shikake - the Japanese art of shaping behaviour through design

Matsumura, Fruchter & Leifer (2014) introduced the concept of Shikakeology to research and understand the underlying mechanisms of shikake in a scientific way. "A shikake is an embodied trigger for behaviour change to solve social or personal problems" (Matsumura et al., 2014, p.419).

A shikake has both physical and psychological triggers. The physical trigger gives the user a psychological trigger that triggers behaviour change. A shikake has three characteristics: it is an embodied trigger for behaviour change, the trigger is designed to induce a specific behaviour, the behaviour solves a social or personal problem. In different triggers are categorised in figure 8.
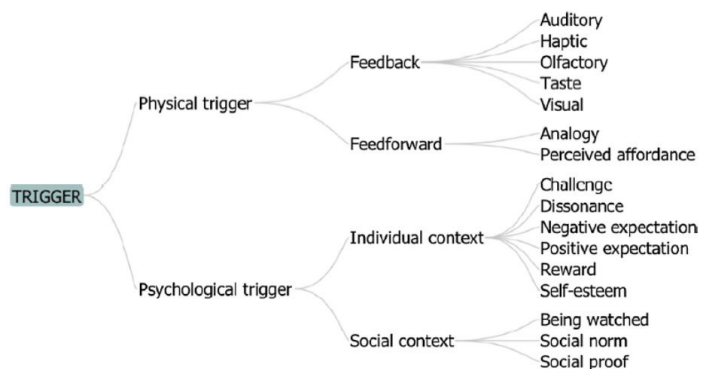

Figure 8: Shikake trigger categories (Matsumara et al., 2014, p. 426)

Psychological triggers are induced from multiple behaviour models. A physical trigger should have good visibility of its function to enable people to intuitively understand the usage and expected result.
Shikakes are used to solve social and or personal problems. Some examples are reducing garbage, traffic accidents, spillage in urinals, and crime. Shikakes aim to solve social or personal problems as the problems stem from our own behaviour, they can be solved by changing that behaviour. The shikake provides a different way of approaching problem behaviours (Matsumara et al., 2014).

It is often the case that a small trigger can change our behaviour and result in a big impact (Andrews, 2009). The fly target engraved on urinals in men's facilities at Amsterdam's Schiphol Airport is a renowned example. The fly target in urinals is a little trigger that induces a slight behaviour shift. Men's conduct is expected to change when they encounter the fly target because they are challenged to aim for it. The result is that spillage has been reduced by 80%. Cleaning costs and water consumption are

Intervention strategies	

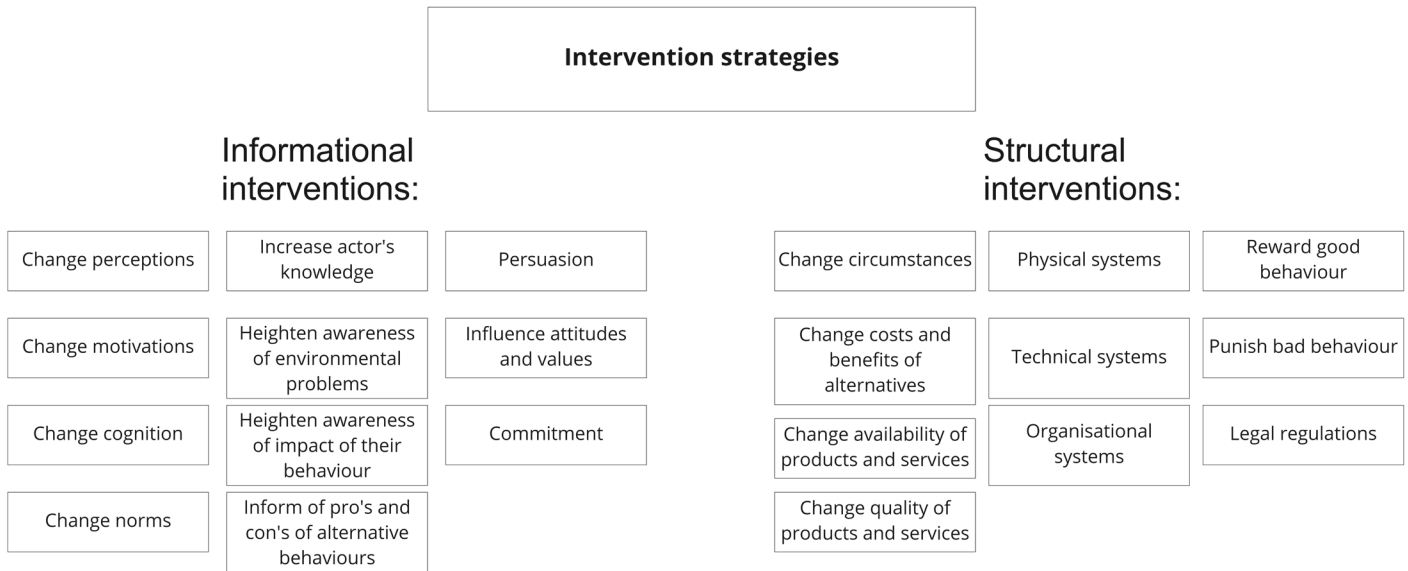| **Informational interventions:**			**Structural interventions:**		
Change perceptions	Increase actor's knowledge	Persuasion	Change circumstances	Physical systems	Reward good behaviour
Change motivations	Heighten awareness of environmental problems	Influence attitudes and values	Change costs and benefits of alternatives	Technical systems	Punish bad behaviour
Change cognition	Heighten awareness of impact of their behaviour	Commitment	Change availability of products and services	Organisational systems	Legal regulations
Change norms	Inform of pro's and con's of alternative behaviours		Change quality of products and services		

Figure 9: Intervention strategies for pro-environmental behaviour (Steg & Vlek, 2009).

both reduced as a result of this. This makes it have a broader influence on environmental pollution reduction (Matsumura et al. 2014).

Environmental Psychology

In the research of Steg and Vlek (2009), two intervention strategies are mentioned. Informational and structural interventions. The informational interventions focus on changing perceptions without changing the physical context and are effective when pro-environmental behaviour is convenient and not very costly in terms of money, time, effort and social disapproval. The structural interventions focus on changing the circumstances and are more costly, but also more effective as only providing information is rarely enough for behaviour change. Examples of the interventions can be seen in figure 9.

SQ4: Which aspects need to be operationalised to conduct an empirical research on the influence of design on behaviour?

The purpose of this thesis is to describe the relation between design and behaviour, and more specific, circular behaviour. In order to do an empirical research on the influence of the design on behaviour, the literature review provided information on what aspects need to be present in a framework to do so.

It is clear that a design has influence on the behaviour of a person, and that there are practices that are focused on influencing behaviour through design. A person might have a positive attitude towards showing a behaviour, but the context can

hinder the person from showing the behaviour. The literature review provides many insights regarding circular behaviour, behaviour theories, and design for behaviour practices. In this section the findings of the sub questions are combined to decide on how to use the information for empirical study. In this sub question, a flexible analytical framework is created which can be used in different settings for different behaviours.

When designing for a certain behaviour, first a specific behaviour has to be chosen to design for. This is mentioned by Wastling et al. (2018) in their first phase of the design for circular behaviour. It is also mentioned by Münscher et al. (2015) as the first step for designing a choice architecture intervention. The first sub question helps with this step. Using the 10R model of Vermeulen, Reikje and Witjes (2018), a list of circular behaviours is provided. However, there should also be problems that need to be solved as the goal of the desired behaviour. As stated in the problem statement, the main problem is that earth's resources are being depleted and a transition towards a circular economy is necessary which requires circular behaviours. Therefore any of the circular behaviours could be chosen in this research.

The third sub question provided the answer that a behavioural model should be used when designing for behaviour change. For the development of the framework in this study, the COM-B theory will be used as it is an integrated model which incorporates most of the aspects found in theories from environmental psychology as well. The COM-B model provides a clear division of different factors

that affect behaviour.

The final finding is that a design technique should be used that focuses on behaviour change. For this research, the choice architecture is chosen because it focuses on the decision-making process. The research of Münscher et al. (2015) provides a clear overview and explanation of all the techniques.

Even though these theories are recommended, a ready to use framework is not provided by the literature. This sub question aims to turn the theoretical knowlede into a practical, ready to use framework. Therefore the next step of this research is to create an analytical framework that can be used to research the influence of design on behaviour. The framework will be made by combining the steps of three frameworks that were found in the literature. The first one is the Design for Circular Behaviour by Wastling et al. (2018). The second one is Choice Architecture by Münscher et al. (2015). The third one is the COM-B model as explained by West and Michie (2020).

The findings of the literature review are combined in an analytical framework which operationalizes the theory. The analytical framework will be tested in the empirical phase of this research and could be used to research the context and the user in different settings and for different behaviours as well. In this section, first it is explained how the analytical framework is built, step by step.

Starting point
The starting point of the creation of the analytical framework is to create a table that shows the status of COM-B subcategories for a specific behaviour. As explained in the literature review, the main categories of the COM-B model act as gates. If all gates are open, it is possible to show the behaviour. If a single gate is closed, it is no longer possible. Therefore it is paramount to find out if any of the gates are closed.

The context and users need to be researched to map the status of the gates. When a closed gate is found, it is possible to make an intervention that can open the gate, allowing the desired behaviour to take place. In the figure 10 an example of what the result of three different researched behaviours could look like is presented. As mentioned in the literature review, not all subcategories have to be positive to show the behaviour, only the three main categories (West & Michie, 2020).

The example result of Behaviour X, shows that all gates are open. Therefore Behaviour X is shown. Behaviour Y has a negative physical capability, which prevents the person from showing the behaviour. This also causes the behaviour to not be habitual, as the person is unable to show the behaviour. All other factors are positive, but one of the main gates is closed. Behaviour Z shows that the social opportunity is negative, and there is not a habitual behaviour, but the person could still show the behaviour without the involvement of other people or organisations. By changing the the social opportunity to positive, it is more likely that the person will show the behaviour.

Aspects that might influence the subcategories:
Figure 10 gives a clear overview of the COM-B model theory and shows which aspects need to change for a person to show behaviour. But the table does not show the reason for why the gate is open or closed. To determine which aspects might affect the different sub categories, the definitions of the subcategories as given by West and Michie (2020) are used to create a new table that shows general aspects that might influence the subcategories. This is presented in table 5. The definitions below can also be found in Appendix B to use as a cheat sheet when replicating the research.

	Capability physical	Capability psychological	Opportunity physical	Opportunity social	Motivation reflective	Motivation automatic
Behaviour X	O	O	O	O	O	O
Behaviour Y	X	O	O	O	O	X
Behaviour Z	O	O	O	X	O	X

Figure 10: Example results for COM-B research for three different behaviours.

COM-B aspect	Design aspect
Capability physical	Distance
	Weight
	Accessibility
	Height
	Thresholds
Capability psychological	Difficulty
	Access to information
	Reminders
	Understanding
Opportunity physical	Availability of inanimate objects
	Duration
	Costs financial
	Costs social
	Distance
Opportunity social	Rules from organisation
	Norms
	Culture
	Participation
Motivation reflective	Informing
	Important factors
	Reminders
	Rewards
	Punishment
Motivation automatic	Cue's
	Triggers
	Direct feedback
	Stable environment

Table 5: General design aspects that might influence the COM-B subcategories, based on the definitions from West and Michie (2020).

The physical capability relates to aspects that influence the physical aspect of behaviour. Whether you are strong enough to lift something up, whether you are able to walk up and down the stairs, and if you can make certain movements. These translate to the generic aspects of distance, weight, accessibility, height and thresholds.

The psychological capability relates to mental aspects such as understanding and memory. The difficulty of the behaviour, having access to information, being reminded or taking lessons might influence the psychological capability.

The physical opportunity is not only the environment or objects, but also about time, financial and material resources. This can be influenced by adding objects to an environment or removing them, by changing the duration of the behaviour can also make it more or less possible as time is a limiting factor. Costs also determine whether someone can pay for the behaviour, and by changing the distance, it also has influence on the duration, but also could result in an increase of financial costs due to travel expenses. The social opportunity relates to how other people and the organisation of a location help or disapprove of the behaviour. This might be influenced by culture, norms or rules. Also having (more) people present at a location might influence the social opportunity.

The reflective motivation is about planning and evaluation of the behaviour. The evaluation first happens by what is already known to the person. By informing people about a behaviour, they can weigh the new pros and cons and might decide to adopt a new behaviour or not. Certain aspects from other aspects will also act as information in the decision making process. For example, the conscious decision not to separate waste because the distance to the bin is regarded as too big. This causes the motivation to be negative, even though the person is physically capable of walking the distance, and has the physical opportunity of time to do it, but a closer bin might also lead to positive motivation to separate waste. Finally, the rewards that might come with a behaviour can lead to a positive motivation, but when the reward is removed, the behaviour can disappear as well.

Finally, automatic motivation is about habitual or instinctive behaviours that are done without conscious thought. Habits react to mental or environmental cue's and triggers. These habits are usually formed by direct-feedback mechanisms. An environment can also trigger automatic behaviours, so a change of environment can lead to breaking habits and forming new ones.

Table 5 lists the general aspects that might influence the subcategories and can be used to translate the table to a specific behaviour.

To operationalise table 5 a column has to be added to check the influence of every aspect. Doing this doubles the size of the table. For every aspect can be researched whether it has a positive or negative impact on the behaviour for each subcategory. Using colour coding the influence will be shown. Green indicates a positive influence, yellow is mixed, red is negative. The text in the box can describe the underlying reason for the influence on the behaviour aspect, providing more information then just the influence. To keep the table legible, table 6 shows a small excerpt of the new table for one of the subcategories.

Capability physical	Behaviour Y
Distance	5m
Weight	100kg
Accessibility	Not wheelchair accesible
Height	1m
Thresholds	Staircase

Table 6: Operationalisation example of table 5 (own creation)

Combining Choice Architecture with COM-B

The next layer in the analytical framework is linking choice architecture techniques to the different categories and aspects. The COM-B model is linked to choice architecture to show what techniques can be used to change the influence of the different factors. According to Münscher et al. (2015), the COM-B model can be used to look for behavioural bottlenecks. In order to make the connection between aspects and techniques, the different techniques and their means are explained in this

Category	Technique
A. Decision information	A 1 Translate information *Includes: reframe, simplify* A 2 Make information visible *Includes: make own behavior visible (feedback), make external information visible* A 3 Provide social reference point *Includes: refer to descriptive norm, refer to opinion leader*
B. Decision structure	B 1 Change choice defaults *Includes: set no-action default, use prompted choice* B 2 Change option-related effort *Includes: increase/decrease physical/ financial effort* B 3 Change range or composition of options *Includes: change categories, change grouping of options* B 4 Change option consequences *Includes: connect decision to benefit/cost, change social consequences of the decision*
C. Decision assistance	C 1 Provide reminders C 2 Facilitate commitment *Includes: support self-commitment/public commitment*

Table 4: Choice architecture categories and techniques (Münscher, Vetter, & Scheuerle, 2015, p. 514)

section based on the research from Münscher et al. (2015). This section can be found in Appendix C to use as a cheat sheet when replicating the research

There are three main categories of techniques. The first category is (A) decision information where the techniques focus on different ways of presentation of relevant information without changing the options of behaviour. The second category is (B) decision structure, which is about changing the arrangement of options, effort needed and consequences. The final category is (C) decision assistance which can be done with reminders or commitments.

A1: Translate information
Information can be translated through the reframe technique. For this technique it is not allowed to provide new information. But for example to reframe information from live-saving to death-preventing does count. Another technique to translate information is to simplify already available information to for example rules of thumb or plain language.

A2: Make information visible
By making (new) information visible people will become aware of invisible consequences. Giving feedback about one's own behaviour can be done for example by a smart electricity metre showing energy consumption. But also external information can be made visible. For example, a label that displays the level of hygiene of a restaurant can help people to avoid a restaurant with a bad label.

A3: Provide social reference point
People do not make decisions or behave in a vacuum but in a social and cultural context. The behaviour of other people influences people's own behaviour. By referring to the descriptive norm, which is what people are doing that can be observed, people can be stimulated to show the same behaviour. It is possible to refer to the group or to the opinion of a respected leader.

B1: Change choice defaults
Defaults are pre-selected options that allow decision-makers to deliberately choose a different option. People accept the default in many instances. The no-action default refers to what happens when a user doesn't make a choice. The opposite is a prompted choice which forces people to decide, which is helpful for a heterogenous group where a default option might not work.

B2: Change option related effort

The amount of effort required has a significant impact on which of the numerous possibilities an individual will select. For this choice architecture technique the change in effort can only be marginal. Else it would count as manipulating standard economic transaction costs. The option related effort can be changed by increase or decrease of physical effort, financial effort or duration of the behaviour.

B3: Change range or composition of options

It is also possible to change the amount of options that are given. People also make decisions based on what the alternatives have to offer.

B4: Change option consequences

By connecting benefits or costs to a decision it is also possible to influence behaviour. This can have monetary or social consequences.

C1: Provide reminders

Sometimes people are aware of all necessary information but need to be reminded of them. These reminders can help to stimulate that behaviour, but there can also be reminders to oppress unwanted behaviours. The reminders are not allowed to provide new information for this technique.

C2: Facilitate commitment

Individuals who make a private or public commitment to certain actions are more likely to follow through because it helps them overcome self-control issues. Not adhering to the commitments can lead to losing face so it stimulates them to stick to the commitment.

Based on the definitions of the separate COM-B categories and choice architecture techniques,

COM-B subcategory	Choice architecture technique
Capability physical	B1, B2, B3
Capability psychological	A1, A2, B1, B2, C1
Opportunity physical	B1, B2, B3, B4
Opportunity social	A2, A3, B4, C1, C2
Motivation reflective	A1, A2, A3, B2, B3, B4, C1, C2
Motivation automatic	A2, B4, C1

Table 7: Combining choice architecture with COM-B based on definitions provided by authors (own creation).

combinations are suggested in table 7. This table helps to speed up the process of selecting suitable choice architecture techniques to found aspects that need to change to enable behaviour.

The framework is extended with an extra column, displaying every choice architecture techniques that could influence the aspects. Table 8 presents the general table with the matching choice architecture techniques and the operationalisation column.

COM-B aspect	Design aspect	Choice technique	Influence
Capability physical	Distance	B1,B2	
	Weight	B2,B3	
	Accessibility	B2,B3	
	Height	B1,B2	
	Thresholds	B2,B3	
Capability psychological	Difficulty	A1,B2,B3,C1	
	Access to information	A2	
	Reminders	C1	
	Understanding	A1,A2	
Opportunity physical	Availability of inanimate objects	B1,B3	
	Duration	B2,B3	
	Costs financial	B2,B4	
	Costs social	B2,B4	
	Distance	B1,B2	
Opportunity social	Rules from organisation	A3,B4,C2	
	Norms	A3	
	Culture	A3	
	Participation	A2,C2	
Motivation reflective	Informing	A1,A2,A3	
	Important factors	depends	
	Reminders	C1	
	Rewards	B4	
	Punishment	B4	
Motivation automatic	Cue's	B1	
	Triggers	B1	
	Direct feedback	B4	
	Stable environment	B1	

Table 8: General table with specific combination of COM-B aspects and Choice Architecture techniques (Own creation)

Research context

The next step is for the researcher to get familiarised with the context and to make a preliminary conclusion about the influence of the context on the different aspects. For this multiple techniques are recommended: visit the location, document analysis, information about the place. Based on this research, newly found aspects can be added to the framework in the appropriate subcategory.

Research user

The next step is to perform interviews with the users/target group. The questions of the interview should be related to the COM-B aspects, but also open questions that can provide answers to multiple

aspects. The findings will update the framework a final time adding new aspects and validate the findings of the context research.

Setting up the analytical framework for the case studies:

For setting up the framework the following steps will be used:

Step 1, Specify desired circular behaviour
Step 2, Translate the general aspects of the COM-B table 8 to the desired behaviour
Step 3, Analyse applicability of choice architecture framework

Step 1, Specify desired circular behaviour
In the scope of this research the problems and desired circular behaviour are mentioned. For this empirical research the behaviours of Reuse/Resell and Recycle Materials are chosen.

Step 2, Translate the general aspects of the COM-B table 8 to the desired behaviour
The COM-B model will be used to research both context and user. For this, the general COM-B table 8 is used to make a starting point on what factors influence the different subcategories. This table will be triangulated and updated based on the findings of context research and interviews with the users.

Step 3: Analyse applicability of choice architecture techniques
For each of the aspects, suitable choice architecture techniques are chosen and added to the table as the third and final step for setting up the framework. The predetermined combination of choice architecture techniques per subcategory helps to speed up this process.

Table 9 shows the translation of table 8 to the specific behaviour of Reuse. Table 10 shows the translation of table 8 to the specific behaviour of Recycle Materials.

Table 9 and 10 will be used as the flexible analytical framework to study the influence of design on the circular behaviours of Reuse and Recycle Materials. During the empirical study, new aspects can be added, aspects can also be removed, and the influence will be mapped as shown in table 6.

COM-B subcategory	Aspect for Reuse	Choice technique
Capability physical	make it easier or more difficult	B2
	Proximity	B1,B2
	Elevator	B2
Capability psychological	Explain how	A2
	Reminders at waste collection	C1
	Clear rules	A2
	Make it visible	A2
	Awareness of digital platform	A2
Opportunity physical	Place to offer items	B1, B3
	Short process and short distance	B2
	low cost or free	B2
Opportunity social	People participate collectively	A3
	Create zero waste norm	A3,B4,C2
	It is allowed by the organisation	B4,C2
	Make culture visible	A2, C2
	Stimulate culture of reuse	A3,C2
Motivation reflective	Provide information on impact of reuse	A1,A2,B4
	Important factors that influence motivation	Depends
	Make it visible	C1,A2
	Remove thresholds	B1,B2,B4
Motivation automatic	Trigger for reuse on the route to garbage collection point	A1,C1
	Offer direct reward for reuse	B4
	New location allows for new habits to form	B1

Table 9: Specific combination of COM-B aspects and Choice Architecture techniques for Reuse (Own creation)

COM-B subcategory	Aspect for Recycle materials	Choice technique
Capability physical	Accesibility	B2
Capability psychological	Inform about what goes where	A1,A2,B2
	Reminders to do it	C1
Opportunity physical	Distance to bins	B2
	Different bins at home	B1,B2,B3
	Different bins at the collection point	B1,B2,B3
	Take away the costs such as buy your own bins	B2
Opportunity social	People participate collectively	A3,B4,C2
	Visible culture	A2, C2
Motivation reflective	Provide information on impact of recycling materials	A2, B4
	Important factors that influence motivation	Depends
	Reward or punish behaviour	B4
Motivation automatic	New location allows for new habits to form	B1

Table 10: Specific combination of COM-B aspects and Choice Architecture techniques for Recycle Materials (Own creation).

METHODOLOGY

In this chapter the research design will be elaborated on. First, the research rationale is presented. Then, the research framework is shown and the type of study is explained. Next the different phases and used methods will be explained in-depth per question. This chapter concludes with the data plan and the research output.

Rationale

The goal of this exploratory study is to describe the relation between design and circular behaviour which is grounded in data obtained from in-depth interviews and document analysis. A flexible analytical framework is created with the findings of the literature study. The subcategories of the COM-B theory serve as sensitizing concepts to gain theoretical sensitivity. The collection of data, analysis, and development of themes all happened at the same time (Bowen, 2006). Using the constant comparative method, new themes and aspects of design were found that influence behaviour (Glaser & Strauss, 1967). The themes are treated as variables to map their influence (Blaikie, 2000).

Research Framework

This research aims to describe the relationship between circular behaviour and design and to make recommendations on future design practice. To do so, several stages of research must take place. The first stage is a literature study. As mentioned in the problem statement, understanding circular behaviour and how it can be influenced is necessary to research how a design can influence those factors that stimulate circular behaviour. A framework is made based on the literature review that will be used to do multiple case studies. The framework will act as a lens to view the cases with to inventorize all factors influencing behaviour. The next stage is the empirical study consisting of case studies with document analysis and semi-structured interviews. In the case studies, student complexes will be researched to what extent the design influences specific circular behaviours. First a document analysis will take place in which general information about the building, floor plans, and organisational structure will be studied. Next, semi-structured interviews will be done with inhabitants of the case study projects to gain more insight in the current situation and in what way the students experience the design in relation to circular behaviours.
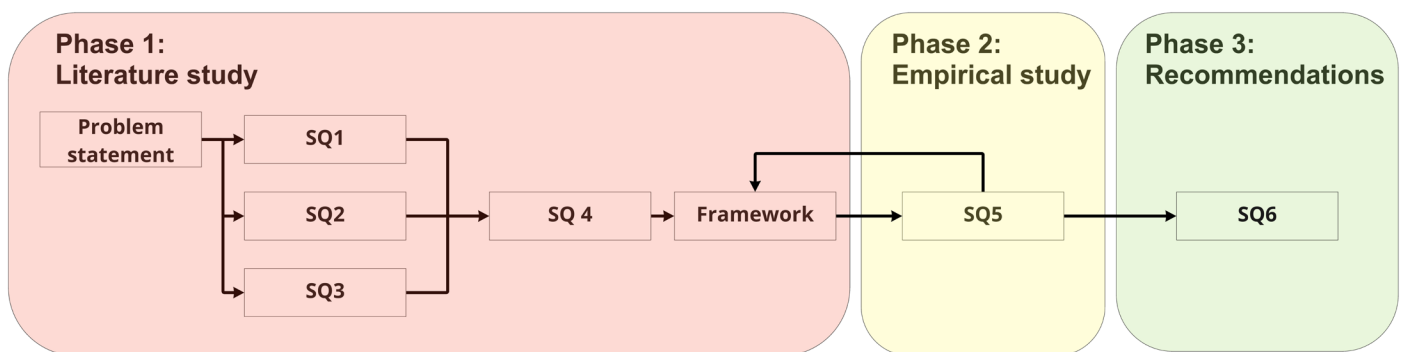

Figure 11: Research framework, the different phases and sub questions

Phase	SQ	Type of study	Method	Data collection
Literature study	1,2,3,4	Qualitative	Literature review	Literature
Empirical study	5	Qualitative	Case studies	Document analysis and semi-structured interviews
Recommendations	6	Qualitative	Research review	

Table 11: Study design overview

Finally, in the last phase recommendations will be made based on the knowledge gained from the theoretical background and case studies for future design practice.
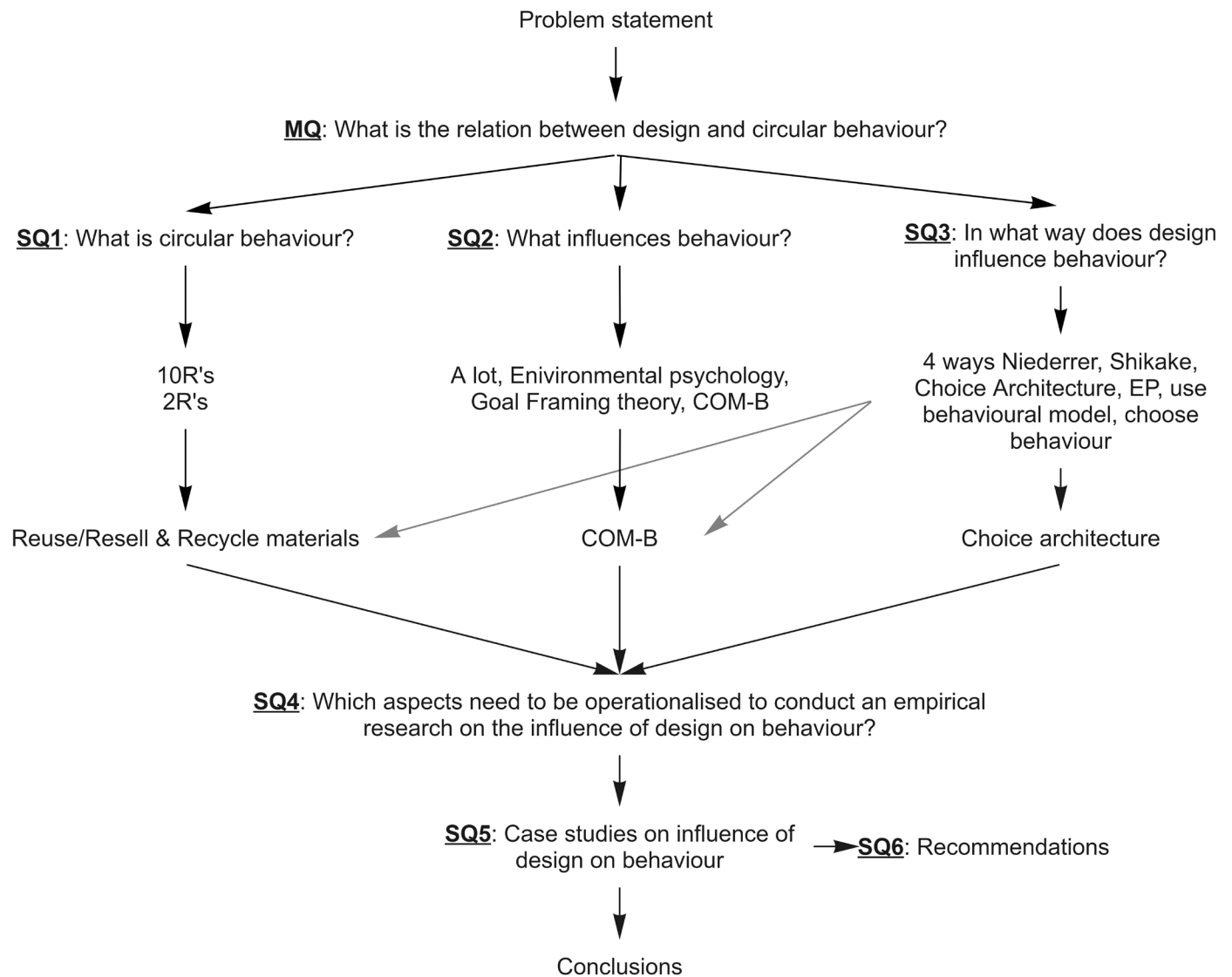

Figure 12: Research design overview

In figure 12 the different sub questions and their relations are shown. In order to answer the main question, the first three subquestions aim to develop understanding of the theoretical background. First circular behaviour is researched, next what factors infuence behaviour, and then in what way a design influences behaviour. The findings of sub question three requires input from the first two sub questions. With the findings of these questions a framework was made which operationalized aspects to conduct an empirical research. In sub question five the framework is used and based on the findings, recommendations and conclusions are made.

Type of Study

The goal of this study is to learn more about the relationship between circular behaviour and design. This research is placed in the academic field of Real Estate Management, which is defined as "facilitating the users of the built environment, while optimally contributing to societal and organisational goals, climate challenges and economic feasibility" (TU Delft, 2021). In order to comprehend the concepts, their context, and what factors may influence the circular behaviour of inhabitants, existing situations and people, in addition to literature, need to be studied. Therefore the chosen research type is qualitative. According to Goodman (2011), meanings, concepts, definitions, qualities, metaphors, symbols, and descriptions of things are all part of qualitative research. Furthermore, by investigating the relationship between circular

35

behaviour and design, using currently available concepts and different perspectives, this research aims to familiarise itself with a phenomenon or concept, or to gain new insights into it, which is a characteristic of qualitative research (Kothari, 2004). Therefore, a qualitative method is chosen for this research.

Phase 1: Literature study

In this phase, the first four sub questions serve to develop an understanding of the background literature and to develop a framework and create input for the next phase in which the case studies will be done. To answer the first set of research sub questions, research will be done in literature. Scientific publications and books are the primary sources of information for this phase, which are found via a variety of educational and scientific search engines such as Google Scholar, the TU Delft Repository, and other online journals and reports. The most used keywords to look for information are, but not limited to: circularity, circular behaviour, measuring circularity, behaviour change, influencing behaviour, design for behaviour change, sustainable behaviour, user-centred design, pro-environmental behaviour, stimulating circular behaviour, circular architecture, social circularity and circular real estate.

There is not yet a straight-forward answer to the question 'What is circular behaviour?' because of the broadness of the term of circularity. Therefore, multiple sources will be used that describe aspects of circular behaviour. Literature regarding measuring circularity, the R-ladders and circular consumption behaviour will be researched. This literature will be filtered to only take into account what circular behaviour in housing looks like, as this is the scope of this thesis. Finally a definition of circular behaviour will be given that is used throughout this thesis.

To answer the sub question 'What factors influence behaviour?' multiple behaviour theories are researched. From those theories, one is chosen to use in the case studies. For the sub question 'How does design influence behaviour?' research is done in the fields of Design for Behaviour Change (DfBC), Design for Circular Behaviour (DfCB), Choice architecture, Shikake and environmental psychology. Finally, in the last sub question of the literature study, all findings are combined in an analytical framework to operationalize the theories.

Phase 2: Case studies

The literature study is supplemented with empirical research in the second part of this thesis to obtain more detailed and contemporary information. In the fourth sub question the result of the literature research is a flexible analytical framework with which the focus for case studies and interviews is determined. It provides input that shows important factors of design that could influence behaviour in order to answer the fifth sub question: "What influence do designs have on the circular behaviours of Reuse/Resell and Recycle Materials of inhabitants in current practice in student housing complexes?" In this second phase, empirical research is done to find how the inhabitants are influenced by the design. The empirical research is based on grounded theory, sensitizing concepts and the constant comparative method.

The framework will be expanded on and adjusted with the gained knowledge from the case studies. This research aims to fill the gap in literature for designing for circular behaviour in housing. The findings of this phase will be used in the final phase for recommendations for future design practice. Two cases are studied in parallel in the same manner. First a document analysis is done which is then supplemented with semi-structured interviews with residents of the studied cases. The interviews will be analysed in Atlas.Ti with open-coding. The findings will be examined and a cross-case analysis will be done.

Phase 3: Recommendations

The first two phases of the research are devoted to performing a literature review and an empirical research in which data is gathered through document analysis and interviews. The third part of this research involves converting the insights gathered in the first two phases into practical suggestions. These recommendations are based on key findings and the created framework. The goal of the recommendations is to provide designers with more insight on how to design for circular behaviour in housing. General recommendations for designing for circular behaviour will be given, as well as for the specific behaviours that are studied in the cases.

Name case	Characteristics	Reason for inclusion	Type
Case A	Renovated univesity building	Unique renovated building	Studio and 2 person
Case B	Mix of studios and shared housing	Gallery layout	Studio and group

Table 12: Case study selection

Selection of case studies:

For the selection of case studies the following criteria are used:

-student complex
-in the Netherlands
-realised
-floorplans available
-currently inhabited

The first criteria is that the cases must be student complexes because this is the chosen scope of the research. It is chosen to focus on projects in the Netherlands so that the cases can be easily visited and inhabitants can be approached for interviews. Also, having all cases in the same country keeps the context surrounding the projects similar. The projects must be realised and currently inhabited by students. This is important to be able to interview the inhabitants and to see what effect the design has in practice, instead of only in theory. Floor plans and other documents related to the project should be accessible to perform document analysis, in order to prepare interviews with inhabitants. In table 12, the case study selection is given.

The cases are included for the following reasons:

Case A is included because it is a renovation of an old campus building. The renovation results in unique layouts and could provide valuable insights for other buildings.

Case B is located in Delft and is included because of it's gallery layout and mix of housing types. It is partially renovated, part newly built. There is group housing and studio's.

By having this list of cases, a mix of old and new, studio and grouped housing is achieved. The findings of the case studies can then be compared among each other.

Case study set up

In order to empirically research the influence of design on behaviour the framework that has been created in the literature study is used. In order to use it, the framework must be translated to the specific behaviours that were chosen in the scope. After that the framework is filled in based on a document analysis. The next step is to create interview questions based on the framework's aspects. Then inhabitants of the cases are interviewed and the findings are filled in to the framework. Finally, a cross case analysis is done to see the differences in influence of design on behaviour. The cross case will allow for deeper understanding and explanation (Miles & Hubberman, 1994).

Data collection

Multiple tools are available to obtain qualitative data in empirical studies, the most frequent of which being interviews, observation, and document reviews (Yazan, 2015). As stated before, this research will only make use of interviews and document reviews. The aim of this study is to gather qualitative data on the relationship between a design and circular behaviour. In order to understand this, not only objective data has to be found from floorplans and other documents, but also subjective data such as the experience of the inhabitants is necessary. The literature research from the first phase also provides a lot of input for what information needs to be collected.

The empirical research is based on grounded theory, sensitizing concepts and the constant comparative method.

Grounded theory is a research method that requires a constant interplay between data collection and analysis to generate a theory during the research process. A grounded theory is derived inductively by collecting and analyzing facts about a phenomenon in a methodical manner (Bowen, 2006).

The grounded theory method's primary methodology is inductive analysis. "Inductive analysis means that the patterns, themes, and categories of analysis come from the data; they emerge out of the data rather than being imposed on them prior to data collection and analysis" (Patton, 1980, p. 306).

For empirical research, the literature study provided input for the creation of a flexible analytical framework. The COM-B theory has subcategories which are used as sensitizing concepts to gain theoretical sensitivity.

The first step for data collection in the case studies is that for every project a document analysis will be done to learn more about the project. Based on the findings, the interview protocol with the inhabitants can be adjusted to suit the specific case. In this way the effect of specific design choices can be gauged in the interview.

The interviews are semi-structured, allowing for enough freedom to adjust the emphasis of the interviews in response to key concerns that emerge from or arise during the interviews. But also to ensure the desired topics are discussed. Because the objective of the interviews is to gain more insight, it is also critical that the interviewees feel comfortable and to make the interview resemble an in-depth conversation rather than asking only fixed prepared questions (Bryman, 2012). With a semi-structured interview it is possible to build rapport, allowing for a more free flow of information.

For every case, six inhabitants are interviewed. According to Galvin (2015), there is no straightforward answer to the question how many interviews are enough. Advice is given to keep doing interviews until there are no more new findings. However, the aim of this research is not to find all design aspects that influence behaviour, but to find how different aspects of design influence behaviour. But to reduce the chance of missing out on many aspects it is chosen to do at least six interviews per case. When conducting only six interviews, the chance of finding aspects that are present for 10% of the population is 48% (Galvin, 2015).

The interview protocol is summarised below. The entire interview protocol can be found in Appendix D.

The goal of the interview is to be able to fill in the framework for all COM-B aspects of the behaviours. Therefore the inhabitants will be interviewed about the two circular behaviours, Reuse/Resell and Recycle Materials, and how they experience the building in showing these behaviours.

The interviewee will be asked in relation to these behaviours to what extent they show the behaviours, if they want to, and if they did so in a previous building they inhabited.

During the interview, probing topics are used for every behaviour. When the answer of the interviewee provides insufficient information about the different COM-B categories, the interviewer probes with generic questions related to the behavioural model.

Every case will have questions with case specific building aspects. These are formulated based on the prior document analysis. After the interview, the interview will be transcribed and analysed in Atlas. Ti to find new aspects that influence the behaviour to add to the framework.

Data analysation

The document analysis is structured in the following way. First, general information about the complex is provided:. the location, year built, organisation, architect, number of inhabitants, reason for inclusion, short history, and goals of the design. Next the framework will be used to fill in how the case affects the different aspects. A floor plan analysis is done, which looks into the building as a whole, but also to the different housing types. The same analysis drawings are made for every case about entrances, staircases and elevators, shared spaces, facilities, garbage collection spaces, minimal and maximum distance to garbage collection. After the structured analysis, also special features of the complex are stated. Finally, the organisation regarding reuse and recycling materials are reported. The document analysis will lead to specific questions that can be asked to interviewees and to ensure the interviewer has knowledge about the context which the interviewee is asked about.

Before every interview, permission is asked to record the interview for the purposes of the research. If permission is provided, the talk will be recorded during the interview to transcribe the interview. The interview is transcribed as soon as possible after it

has been done. If done soon after the interview the conversation is still fresh in the memory so additional remarks can be written down. To analyse the interviews, Atlas.Ti software will be used. The following actions are done when employing this technique: The interviews will be initially transcribed verbatim. Following the transcription, the whole transcript will be read and any relevant or useful material will be highlighted according to predetermined themes of the COM-B subcategoires, but also new themes can be added. In an iterative process, coding will be added or removed.

The newly found aspects are treated as variables to map the influence on the subcategories (Blaikie, 2000).

Themes arise from the data during analysis, reflecting the essence of meaning or experience derived from various circumstances and contexts, resulting in a grounded theory. "Thematic analysis involves the search for and identification of common threads that extend throughout an entire interview or set of interviews. … Frequently, these themes are concepts indicated by the data rather than concrete entities directly described by the participants" (Morse &Field, 1995, p.139). The quote on thematic analysis reflects on interviewing as a method of data collection, but is not limited to that method. The themes that are found are categorized in the flexible analytical framework.

The constant comparative method is used when analyzing the data, which is characterized by an iterative process (Glaser & Strauss, 1967). To find new aspects, but also to map the influence of the aspects, the data from the different transcripts was constantly compared to prevent repetition of similar aspects in the framework. To detect similarities, differences, and general patterns, each theme was regularly compared to all other themes.

Themes formed gradually as a consequence of a combination of the reasearcher's familiarization with the data, logical associations with the interview questions, and by taking into account the findings of the literature study.

The document analysis was assigned less weight in the analysis than interview data. As the experience of the interviewees of the design is more important. If they perceive something as closed, even when it is open, it is more valuable to have the insight that it is perceived as closed.

Data plan
In the second phase a lot of data is obtained from interviews. The information gathered is primarily based on people's opinions and experiences, as well as other (business or organisation-specific) information that may be sensitive and so requires protection. The paragraphs that follow go over the handling of the sensitive information in more detail.

Data protection
The data produced in this research will be handled and published following the FAIR Guiding Principles (Wilkinson et al., 2016). The acronym FAIR stands for: Findable, Accessible, Interoperable, and Reusable. This means the following for this research:

-After completion this thesis will be published in the repository of the Technical University of Delft (TU Delft). This site can be accessed with the following link: https://repository.tudelft.nl. All sources, whether from literature, interviews, or other sources, will be referred or cited to in APA format, with a full reference list included in the research's references chapter at the end of the thesis.

-All data gathered, whether from literature, interviews, or other sources, will be referred or cited in APA format, with full references available in the research's references chapter.

-The final research document will not include interview transcripts and other data not directly attached to the research, but can be retrieved upon request by sending the author an email using the aforementioned email address. Transcripts and other data that interviewees or organizations have not given permission to distribute will not be shared.

-To protect the confidentiality of the research participants, all sensitive information (e.g. company/organisation specific or personal data) will be anonymized, obscured, or left out upon their request.

Ethical considerations
In addition to following the FAIR Guiding Principles, the research also considers ethical issues to guarantee that no harm is done during and after the research is published. Anonymity, confidentiality,

and informed permission are three important ethical concerns that should be considered when conducting qualitative research (Sanjari et al. , 2014). It will be attempted to make participants' statements less traceable in order to address these ethical concerns and to ensure that no harm is done to them as a result of the publication of their ideas and reflections. This will be accomplished by excluding names and instead focusing on functions and types of organisations. Also, permission to voice record for research purposes will be requested prior to each interview, and this question will be asked again at the start of the recording of the interviews.

SQ5: "What influence do designs have on the circular behaviours of Reuse/Resell and Recycle Materials on inhabitants in current practice in student housing complexes?".

In order to answer this sub question, the flexible analytical frameworks that were created in SQ4 are used. As explained, the framework allows for adding new aspects of design that influence behaviour, and maps the influence of the different aspects with colour-coding and textual explanations.

In this chapter the findings of the empirical research are presented. This will provide input for answering the main question of this research to describe the relationship between design and circular behaviour.

In this chapter, two cases are studied in-depth and are then compared to each other in a cross case study. First the context of the cases is studied through documents and then the inhabitants are interviewed to research how they experience the influence of the design on their behaviour.

4.1 Case A

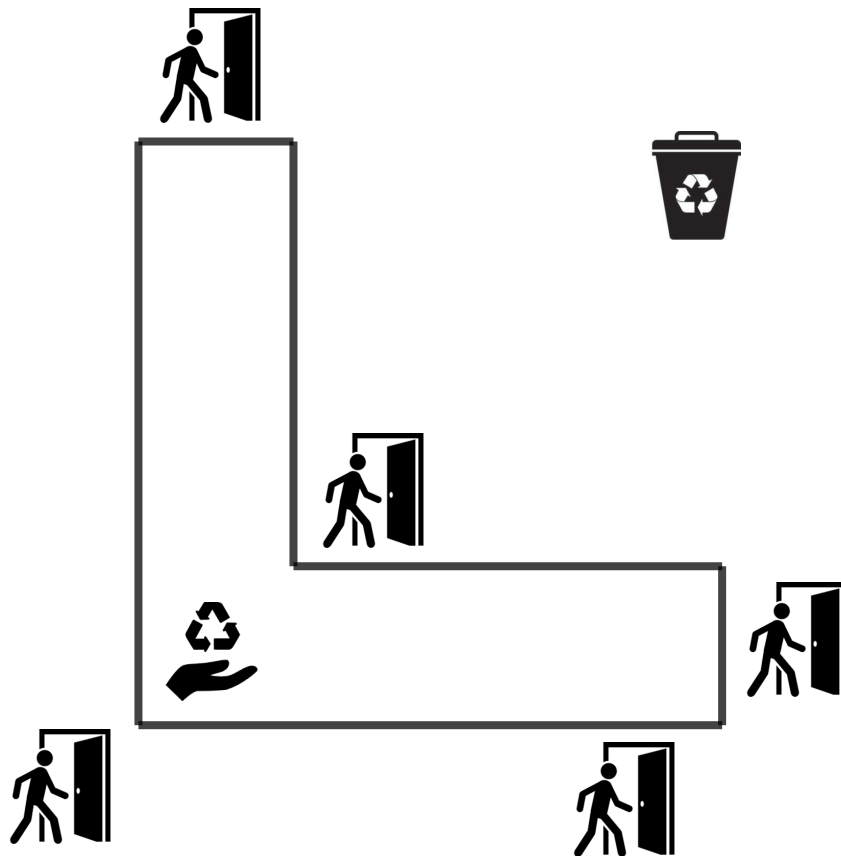Figure 13: Schematic floorplan of Case A

Year built	1920's renovated in 2010's
Number of inhabitants	Approximately 100
Type of housing	Studios and 2 person housing
Reason for inclusion	Convenience, Renovated building, Studios

Part 1 - context research

General information

Case A has a monumental status. Its construction took place around 1920's. Its original function was a school building. Around 2010 the building was renovated by a housing association to a student housing complex. In the renovation it had been decided that the quality of the building should be maintained, and that the program of housing should adjust to the building. Most aspects of the building have stayed the same. It was deliberately chosen not to put as many houses as possible, but to keep the quality of housing as high as possible.

Main features:

After studying the floor plans the following features are found. The building has two main axes and multiple entrances. It has varying sizes of studios of around 30m2. The grand entrance of the building is located on the bottom left of figure 14 and there are multiple side-entrances. There are four multilevel staircases and there is an elevator near the grand entrance. Garbage collection of the building takes place outside on the parkinglot.

The building has four main types of housing units but also many unique types.

Special features:

Because of the renovation and the decision to keep the architectural quality of the building high, the amount of square metres that are non-rentable are much higher than in a newly built student complex. The result is that there are some void spaces and large hallways.

Organisation for Reuse/Resell:

When moving out, it is possible for the tenant that is leaving to make his own arrangements with the new tenant about any items that could be taken over. An example would be to sell the floor or a fridge to the new tenant. But it is the responsibility of the tenant to arrange this handing over of items to the new tenant. The housing association offers a handover form on their website to help facilitate this process. In this document it is clearly stated that the new owner understands that it is his responsibility to get rid of the items when he moves out when the new tenant does not want the taken over items. The housing association also allows for students to mention what items they have that could be taken
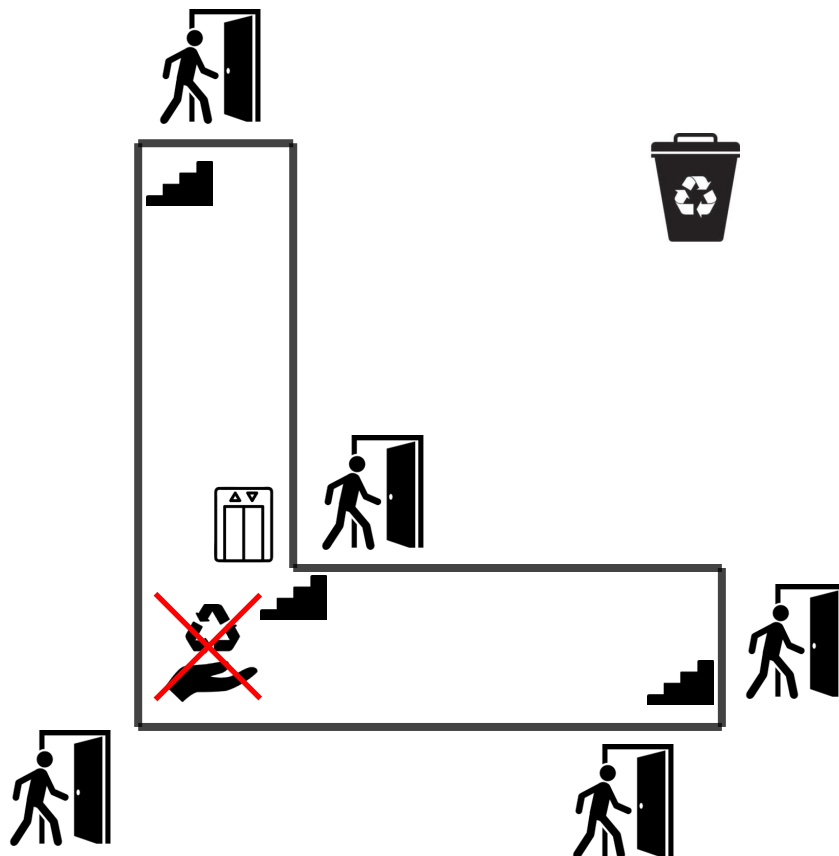

Figure 14: Schematic analysis of ground floor, multiple entrances and location of reuse and waste collection of Case A

over on the advertisement of the room. This way, the potential new tenants already know that there are items that can be taken over.

In the building at the main entrance hall is a small sign that states it is forbidden to put bulky waste there or to offer stuff for free. The red dot in figure 15 indicates the location of a poster which states it is prohibited. If people do place things in the hall, they will be removed without warning and costs will be added to the service costs divided among all residents. This might prevent people from reusing items within the building through the entrance hall.

Organisation for Recycle materials:

The building facilitates a waste collection point outside shown with the symbol of a garbage can on figure 14. The distance toward this point is between 50m and 150m. There are 6 bins for rest waste, 2 are dedicated to PMD, 2 for paper, 3 for glass and 1 for organic waste. On the website of the housing association, information can be found on what waste goes where, and where to find containers that are not in your building.

Preliminary COM-B aspect findings

Based on this context research, the preliminary framework can be filled in for both behaviours. In the paragraphs below, a short explanation for the aspects from table 13 and 14 is given. A green marking indicates a positive influence on the aspect, a yellow marking a positive and negative

Figure 15: Schematic analysis of ground floor, multiple entrances and location of reuse spot, Case A

one, and red is a negative influence. If left blank, no information regarding the aspects has been found and is to be found with interviews.

Reuse:

For the physical capability of reuse an elevator makes it easier to transport heavy objects through the building.

The psychological capability is influenced by the housing association by providing a service that allows tenants to contact new or old tenants to sell or give objects for reuse.

The physical opportunity is given by this same service that allows the users to place objects on the website for reuse. This also shortens the duration of finding someone that might want to reuse the objects. The use of this service is free. However, it is prohibited to offer objects in the entrance hall for reuse, this might lead to costs that are paid for collectively by the residents of the building. Therefore, the influence is mixed for those aspects. No aspects have been found that directly influences motivation, so this requires more research.
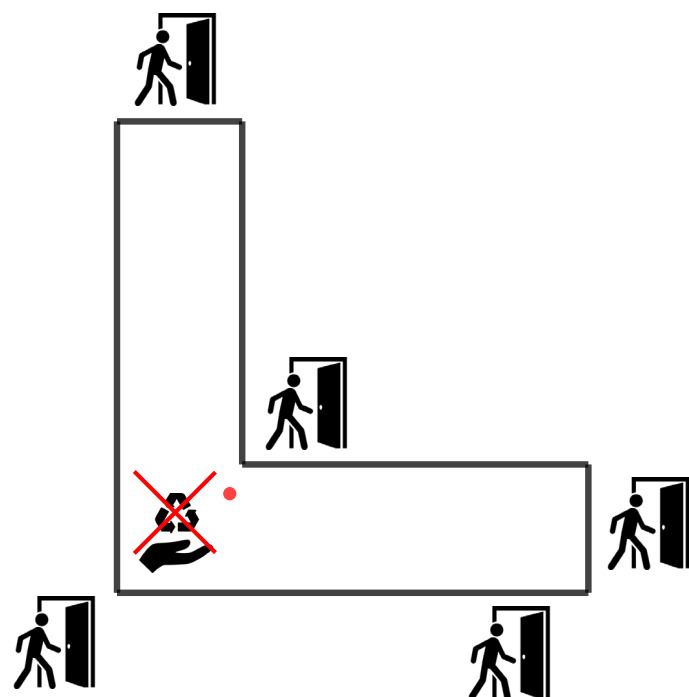
COM-B subcategory	Design aspect for Reuse	Choice technique	Case A
Capability physical	Difficulty	B2	Easy
	Proximity	B1,B2	-
	Elevator	B2	Present
Capability psychological	Explain how	A2	When moving
	Reminders at waste collection	C1	-
	Clear rules	A2	When moving
	Visible	A2	-
Opportunity physical	Place to offer items	B1, B3	Advertisement
	Short process and short distance	B2	Present
	low cost or free	B2	Free for advertisement, collective cost for entrance hall
Opportunity social	People participate collectively	A3	-
	It is allowed by the organisation	B4,C2	When moving yes, in building prohibited
	Make culture visible	A2, C2	When moving
	Stimulate culture of reuse	A3,C2	When moving
Motivation reflective	Provide information on impact of reuse	A1,A2,B4	-
	Important factors that influence motivation	Depends	-
	Visible	C1,A2	-
	Thresholds	B1,B2,B4	-
Motivation automatic	Trigger for reuse on the route to garbage collection point	A1,C1	-
	Offer direct reward for reuse	B4	-
	New location allows for new habits to form	B1	-

Table 13: Findings of document analysis in the analytical framework for Reuse in Case A

Recycle materials:

For physical capability only obstacles in the way are measured but none has been found other then that

the building is not wheelchair friendly.

The psychological capability could be influenced by the provided information on the website on how to separate waste and where to find the bins. The building provides multiple bins for paper, glass, PMD, organic, and rest waste, so this has a positive influence on the physical opportunity. However, no data is found on whether there are bins at the homes as well. The distance to the garbage collection point is between 50m and 90m. This is marked yellow as 50m is a much shorter distance than 90m. So depending on where you live in the building, a user could have a positive or negative influence on their physical opportunity. For all the other aspects, no data has been found and requires more research

COM-B subcategory	Aspect for Recycle materials	Choice technique	Case A
Capability physical	Accesibility	B2	Present
Capability psychological	Inform about what goes where	A1,A2,B2	On website
	Reminders to do it	C1	-
Opportunity physical	Distance to bins	B2	50-90m
	Different bins at home	B1,B2,B3	-
	Different bins at the collection point	B1,B2,B3	Present
	Take away the costs such as buy your own bins	B2	-
Opportunity social	People participate collectively	A3,B4,C2	-
	Visible culture	A2, C2	Bins are visible
Motivation reflective	Provide information on impact of recycling materials	A2, B4	-
	Important factors that influence motivation	Depends	-
	Reward or punish behaviour	B4	-
Motivation automatic	New location allows for new habits to form	B1	-

Table 14: Findings of document analysis in the analytical framework for Recycle Materials in Case A

Part 2: User research

Based on the different aspects of table 13 & 14, interview questions are made to research if these aspects are perceived as hypothesised. The interviews will also explore if there are other factors at play that might influence the behaviour and are then categorised according to the behaviour model and added to the framework. For the new factors, suitable choice architecture techniques will be recommended. The interview protocol used can be found in appendix D.

Reuse

Findings interviews for Reuse:
The findings that are presented in table 15 are explained in detail per COM-B subcategory in the section below.

The location of a reuse point has been mentioned by all interviewees which has a central location in the building. This means it is close to most of the people in the building, giving it a positive influence for proximity and makes it more easy to use.

For psychological capability, it is mentioned by all interviewees that there are no clear rules for the reuse location. Interviewee 5 referred to the situation as "Mayhem". She stated that sometimes people take things that are not meant for reuse but are temporarily stored there while moving. Interviewee 3 & 6 were not aware that placing objects in the entrance hall is forbidden by the housing association. The other interviewees stated that it is forbidden but that they don't care. So clear rules regarding the reuse location are missing. When asked about rules the interviewees said there is a sort of common understanding that you can not place thrash, only valuable things, but that what is valuable to one might be regarded as thrash by someone else. There is also a facebook group of the building where people actively offer items for money, or post that they put something in the entrance hall to pick up for free. Interviewee 2 was not aware of this facebook group.

The physical opportunity to place items is given by the housing association when moving to place an advertisement on their website when moving out. Another physical opportunity is made by the residents in a sense that they use the entrance hall as a location to offer things, even though it is not allowed by the housing association. The central location and way of using the entrance hall gives the behaviour a short duration. Due to the joint costs of using the entrance hall, but being able to place it for free the influence is mixed. None of the residents mentioned that they refrain from using the entrance hall for placing items due to collective costs. Providing information to the housing association about reusable items when moving is free and simple to do. Interviewee 2 also mentioned that there is a billboard in the entrance hall that sometimes has an advertisement for furniture to buy second-hand in the building. Due to the entrance hall being closer than the waste facility for most of the residents, it takes a shorter time to offer it for reuse then to throw it away, making it more convenient to allow reuse.

COM-B aspect	Design aspect for Reuse	Choice technique	Case A
Capability physical	Difficulty	B2	Easy
	Proximity	B1,B2	Central location
	Elevator	B2	Present
Capability psychological	Explain how	A2	Advertisement, vague for entrance
	Reminders at waste collection	C1	Stimulating to throw away
	Clear rules	A2	Prohibited at entrance, but people do it anyways, drop-off, mayhem
	Visible	A2	prohibited, but visible
	Awareness of digital platform	A2	Not all interviewees know about facebook group
	Note that you can take it	A2	-
Opportunity physical	Place to offer items	B1, B3	Advertisement, Entrance but not clear
	Short process and short distance	B2	present, max 75m
	low cost or free	B2	joint costs, free placing
	Advertisement for next tenant	A2,C1	Present
Opportunity social	People participate collectively	A3	Present
	It is allowed by the organisation	B4,C2	When moving, but prohibited at entrace, but people do it anyways
	Make culture visible	A2, C2	Present
	Contact with previous and next tenants	A2	Present
Motivation reflective	Provide information on impact of reuse	A1,A2,B4	Missing
	Make it visible	C1,A2	Present
	Low costs	B2	Present
	Hygiene	-	Depends on item
	Convenience	B2	Present
	Moving to studio needs more things	B1,B3	Present
	Good quality items	-	Depends on person and object
Motivation automatic	Trigger for reuse on the route to garbage collection point	A1,C1	Depends on route
	Offer direct reward for reuse	B4	Missing
	New location allows for new habits to form	B1	Present

Table 15: Findings of interviews in the analytical framework for Reuse for Case A

For social opportunity, it is stated by all interviewees that neighbours are active in reuse. Both when moving in and out, and that a lot of stuff is offered in the entrance hall. Interviewee 5 stated that the sign that prohibits the reuse shows that the housing association promotes waste by prohibiting the reuse potential. Interviewee 3 mentioned that the high amount of reuse is due to the strong community and many master students living in the building. In other student complexes the interviewee lived, the residents were not as active on the facebook group.

For reflective motivation, there are a couple reasons given for why the users choose to reuse. One had to do with financial reasons, interviewees 1, 5 & 6 mentioned it is cheap or free so therefore they reuse. As a student, they have a low budget and reusing is a cheap way of getting things they need. Interviewee 5 did mention she wants money for stuff that she offers, to get back a bit of the investment. Because the reuse place at the entrance is close and visible, interviewees stated that they would put items at the entrance hall first for a week or two and then throw

it away if no one took it. When taking over things, hygiene or cleanliness is also mentioned as a factor by interviewees 3 & 4, but interviewee 5 stated she does not mind cleaning an item to reuse it. If an item is very dirty or for personal use, the item will not be taken over. Interviewee 4 took a couch from the entrance hall after being informed by a neighbour that it was available, but bought a new cover for the couch due to hygiene factors. Interviewee 1 stated that she reuses because it is sustainable, and she prefers to do it in the building or with other students as she thinks it is more reliable than from complete strangers living in unsafe areas. Interviewee 2 stated that he reuses the items from the entrance hall because the items are of good quality.

For automatic motivation not many aspects are mentioned. When walking past the entrance hall, the inhabitants are triggered to take something or not. So out of instinct they might grab something. There could also be the habit to take an extra step toward the hall to see if something is offered in the entrance hall.

Mapping influence of design on behaviour

Based on the findings of the interviews following the different subcategories of the COM-B model, a sort of customer journey can be made for every interviewee on how they experience the design of the building in showing their behaviour. Based on all different experiences of the interviewees, the influence of design on different main categories of the COM-B model are presented for Reuse/Resell. In figure 16 the different customer journeys of the interviewees 1, 2, and 4 are presented. In figure 17 the different walking routes of the interviewees are presented.

Reuse, interviewee 1

For example, interviewee 1 was already very motivated to reuse. Because she moved into a studio, she needed many new things such as chairs, bins, and a table. She also has pro-environmental values which influence her to show sustainable behaviour. The design of the building made sure she was capable of reuse in the building as the main entrance and the rest of the building are accessible to her. The elevator increases the accessibility by allowing her to move heavy objects to the first floor. The position of the reuse location makes sure it is visible when an item is available for reuse when she enters the building. So the final factor that determines if she can reuse is the opportunity. The availability of an object to reuse is mandatory to show the behaviour, but the object must also be visible. In the entrance hall the item is offered for free, and its location next to the elevator and close to her own home makes it very convenient to take items. All these factors result in her showing the behaviour of Reuse. In figure 16 the design principles that influenced her are shown per COM-B category.
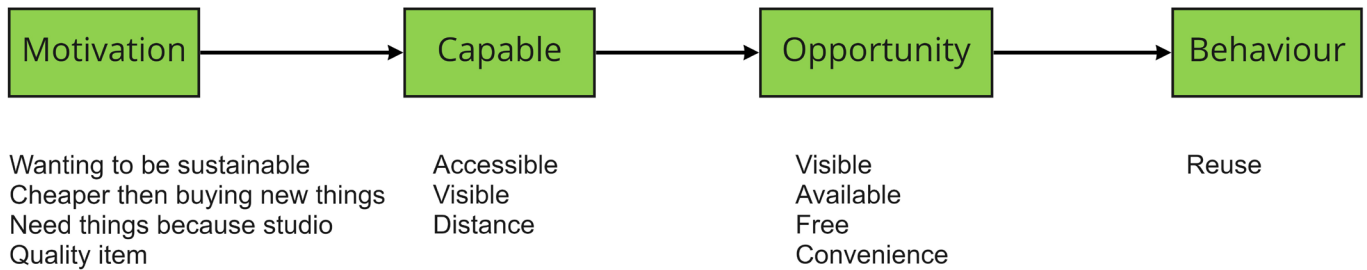
Reuse, interviewee 2

Interviewee 2 was influenced in a different way by the building design to reuse. He did not start with the motivation to reuse, he was motivated because of the way the building is designed. The high degree of capability and opportunity provided him with the motivation to show the reuse behaviour. Because the location is accessible, visible and close to his house, he is capable of using the location. Because the location is visible, an item is available, the item is free, and the time to show the behaviour is short as it is on his way towards his home, these factors make it convenient and motivate him to take the item which he also considered to be a quality and aesthetic item that he could use.
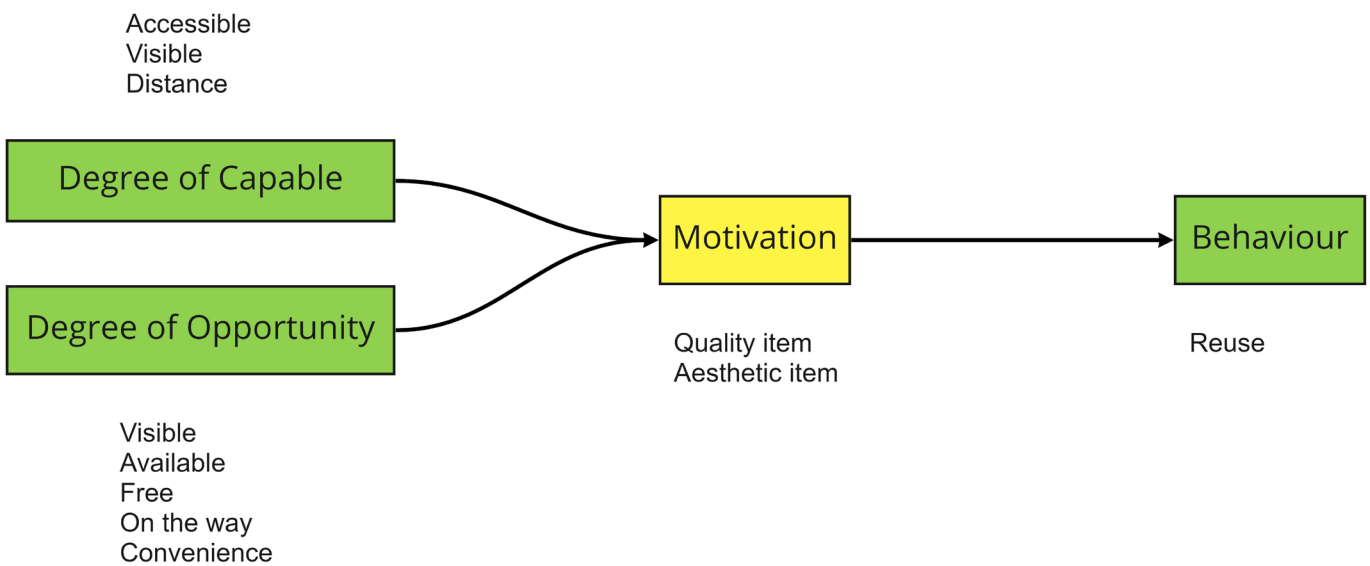
Reuse, interviewee 4

Interviewee 4 is negatively influenced to reuse in the entrance hall of the building because he rarely uses the main entrance. Because the building has multiple entrances, depending on where you live in the building, it is less convenient to use the main entrance. For him, the items that are offered are not easily visible, and are not on his way. So if there would be an item offered that he might need, he can only find out by a chance encounter when he decides to take the main entrance or if a neighbour informs him that there is something there. In this case he was informed by a neighbour that a couch was available and this allowed him to reuse that couch, but no other items are reused from the entrance hall by him.

Interviewee 1 Reuse

| Motivation | → | Capable | → | Opportunity | → | Behaviour |

Wanting to be sustainable
Cheaper then buying new things
Need things because studio
Quality item

Accessible
Visible
Distance

Visible
Available
Free
Convenience

Reuse

Interviewee 2 Reuse

Accessible
Visible
Distance

| Degree of Capable |
| Degree of Opportunity |
→ Motivation → Behaviour

Quality item
Aesthetic item

Reuse

Visible
Available
Free
On the way
Convenience

Interviewee 4 Reuse

Accessible
Not directly visible
Not known when available

| Degree of Capable |
| Degree of Opportunity |
→ Motivation → Behaviour

Might need an item

No Reuse

Available but not directly visible
Unknown when available
Free
Not on the way
Not very convenient

Legend

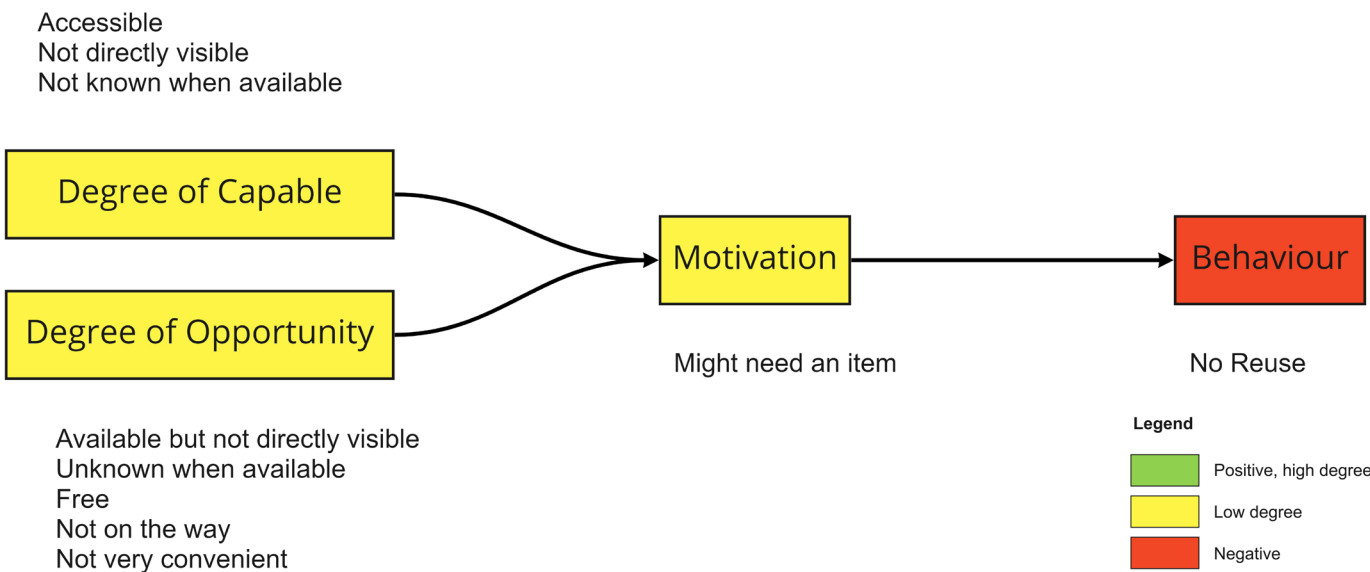█ Positive, high degree
█ Low degree
█ Negative

Figure 16: The design aspects that influence behaviour mapped in order according to the COM-B model for Reuse in Case A
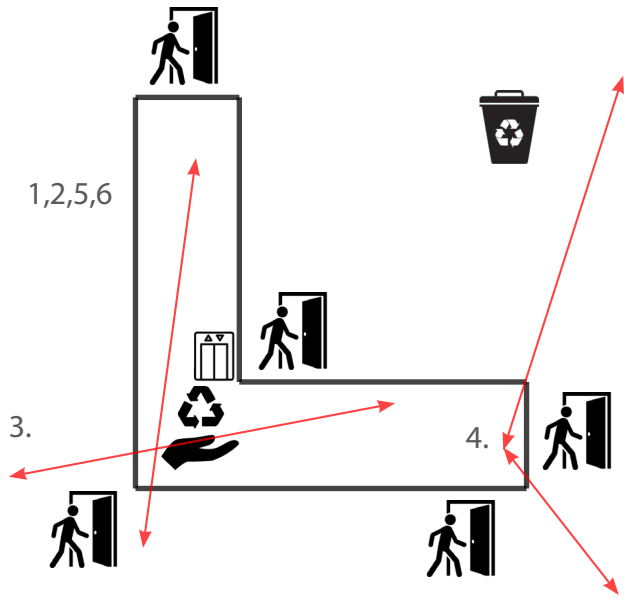
Figure 17: Walking routes of interviewees for Reuse in the building of Case A

COM-B aspect	Design aspect for Recycle Materials	Choice technique	Case A
Capability physical	Accesibility	B2	Present
	Elevator	B2	Present
Capability psychological	Inform about what goes where	A1,A2,B2	Other people
	Reminders to do it	C1	There are bins to separate at the collection point
	Visible	C1,A2	Present
Opportunity physical	Distance to bins	B2	50-90m
	Different bins at home	B1,B2,B3	Not standard, small studio lacks space
	Different bins at the collection point	B1,B2,B3	Present
	Take away the costs such as buy your own bins	B2	Missing
	Capacity bins for building	B2	Paper
	Size of studio	B2	Too small
Opportunity social	People participate collectively	A3,B4,C2	present, not properly, collection point neglected
	Visible culture	A2, C2	Present, collection point out in the open
Motivation reflective	Provide information on impact of recycling materials	A2, B4	Missing
	Reward or punish behaviour	B4	Missing
	Convenience	B2	Depends on location
	Stinking bins	B4	For some interviewees
	Not wanting to put effort	B2	For some interviewees
	No one is forcing	A3,C2	No control
	Roommates do it	A3	-
	Environmental reasons	A2	For most interviewees
Motivation automatic	New location allows for new habits to form	B1	Present

Table 16: Findings of interviews in the analytical framework for Recycle Materials for Case A

Recycle Materials

Findings interviews for Recycle:

The findings that are presented in table 16 are explained in detail per COM-B subcategory in the section below.

For physical capability, as mentioned in the context research, there aren't many factors that can come into play except for accessibility. Everyone should be physically able to throw away trash.

For psychological capability however, it is not clear. During the interviews it has been stated by all interviewees that they mostly learned how to separate waste from other people. They have never been properly informed as to what goes where so when going into detail about separating waste it

becomes clear that the interviewees don't know it well. Interviewee 2 stated that because he is an international, he had to put extra effort in learning how to separate waste as most information was in Dutch. He would like to have been informed more about waste separating in the Netherlands. Interviewee 1 & 5 stated that they are frustrated from seeing neighbours not separating waste properly with pizza boxes ending up in the paper bin instead of the rest bin. This shows that some neighbours do not understand how to separate waste properly, but they are motivated to do it. Interviewee 2 stated that the different bins at the collection point act as a reminding trigger to start separating waste. The first time you might not know it is possible to separate waste in the building, but when you throw your waste away for the first time, you see the different bins and learn it is possible.

Regarding the physical opportunity, the interviewees both directly and indirectly mentioned that the housing they live in did not come with several bins to separate waste. Interviewee 1, 3 & 4 stated to have bought extra bins for separating waste. Interviewee 5 & 6 stated that they do not have the space for extra bins. The small size of the studio has been mentioned as a reason not to be able to place several bins. All interviewees do state that they have the opportunity to offer separated waste at the garbage collection point. Interviewee 3 stated that he would like to separate organic waste as well, but that the building does not offer a bin for the collection. However, there is the physical opportunity to offer organic waste but it is a small bin that is hidden between other bigger bins. This led to interviewee 5 thinking there is a negative physical opportunity making him refrain from the behaviour. The costs for buying own bins and the time to do it has been mentioned by interviewees 2, 4, 5 & 6 as a negative influence on their decision to separate waste, but interviewee 2 & 4 did start separating waste. Interviewees 2, 5 & 6 stated that the capacity of the paper bin at the garbage collection point is insufficient.

For the social opportunity, the interviewees were asked about participation of neighbours in separating waste. All interviewees responded that they don't really know, but looking at the overstacked paperbin, interviewee 2, 5 & 6 mentioned that it suggests that they do. Interviewees 1 and 5 stated that it is frustrating to see that people separate paper wrong, showing that the neighbours are not really participating well in recycling materials. This indicates a negative psychological capability of neighbours but positive motivation, because of all the pizza boxes that end up in the paper bin instead of the rest bin. Interviewee 2 stated that the waste collection point often looks neglected and dirty. This has a negative effect on that person, but his motivation to separate waste is not influenced by it. Because of the waste collection point being out in the open, the culture for waste is visible, however it is not yet positive due to the aforementioned reasons.

For Reflective motivation, the following reasons were mentioned. Interviewee 4 mentioned that he lives close to the waste collection point. And that he also passes this point on his daily trip to the supermarket. This makes it so convenient for him that he started separating more waste. Interviewee 4 also stated that he started separating more waste due to his parents also separating waste, and during summer time his bin would smell because of the heat. By separating plastic he was able to reduce the smell by having a small bin for rest waste. Interviewees 1, 5 & 6 stated that the waste collection point is so far away and that this is a factor that makes them dislike throwing away the thrash, and they feel like they have to walk even more when they start separating waste. A reason for not separating waste stated by interviewee 5 is that no one is forcing her to do it. Also, she does not really believe in the waste collection system. She does feel ashamed for not separating her waste but justifies herself with the arguments of having a small room, not wanting to live in a waste facility, and not wanting to walk the long distance more often. She was also convinced that it would smell a lot if she started separating waste. Interviewee 3 stated that he will separate waste no matter where he lives, but that it does have to be facilitated by the municipality. Else it will become impossible. He stated that he mostly does it because of his pro-environmental values.

For automatic motivation no aspects have been found. It can be implied that the people who separate made it into a habit. Even though it is mentioned by one interviewee that she does not always separate waste, indicating that the behaviour requires a bit of conscious effort.

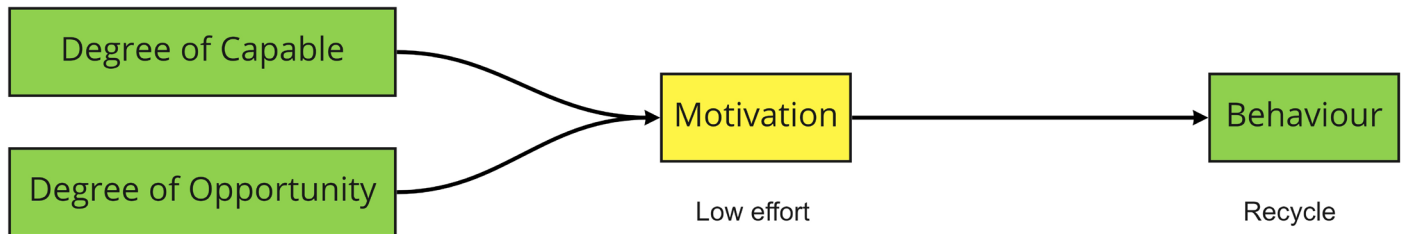## Mapping influence of design on behaviour

Based on the findings of the interviews following the different subcategories of the COM-B model, a sort of customer journey can be made for every interviewee on how they experience the design of the building in showing their behaviour. Based on all different experiences of the interviewees, the influence of design on different main categories of the COM-B model are presented for Recycle materials. In figure 18 the design principles that influenced interviewee 2, 3, 5 & 6 are shown per COM-B category. In figure 19 the different walking routes per interviewee are presented.

Recycle Materials, Interviewee 2

Interviewee 2 mentioned that he started separating his waste because of the design of the building. The first time he went to the waste facility he realised there was the opportunity to separate his waste. This got him motivated to start separating waste at home because the waste facility is designed in
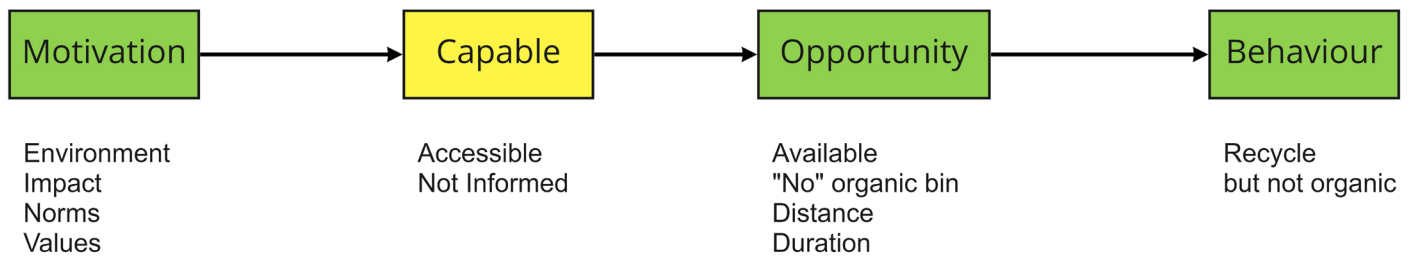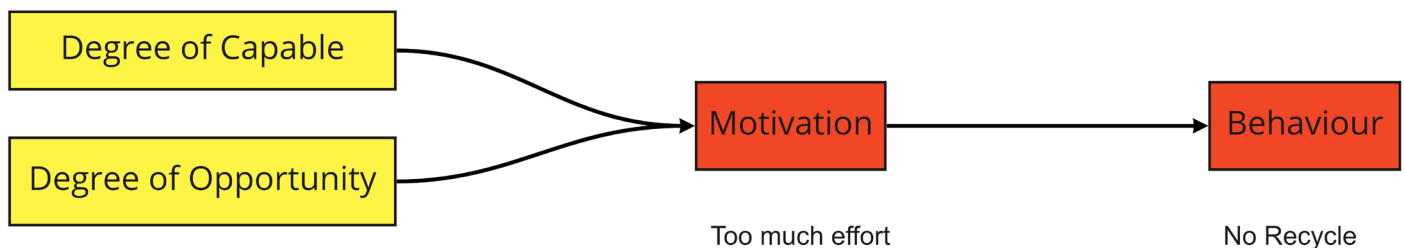
Interviewee 2 Recycle

Accessible
Inform
Visible

| Degree of Capable |
| Degree of Opportunity |

→ Motivation

Low effort

→ Behaviour

Recycle

Available
Capacity
Distance
Duration
Costs
Size of studio

Interviewee 3 Recycle

Motivation → Capable → Opportunity → Behaviour

Motivation	Capable	Opportunity	Behaviour
Environment	Accessible	Available	Recycle
Impact	Not Informed	"No" organic bin	but not organic
Norms		Distance	
Values		Duration	

Interviewee 5 & 6 Recycle

Accessible
Not informed
Visible
Distance is too far

| Degree of Capable |
| Degree of Opportunity |

→ Motivation

Too much effort

→ Behaviour

No Recycle

Available at collection
Not available at home
Distance is too far
It is not convenient
It is not on the way
Size of studio

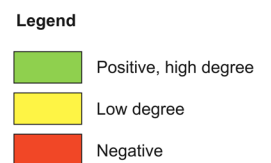**Legend**

🟩 Positive, high degree
🟨 Low degree
🟥 Negative

Figure 18: The design aspects that influence behaviour mapped in order according to the COM-B model for Recyle Materials for Case A

a way that all different bins are visible and close to each other. However, the design failed to inform him on what waste is regarded as paper and what is not. He separates waste on intuition, which might lead to offering the wrong items in the wrong bins. The design fails to inform him on the proper practice of the behaviour. Also the capacity of the bins is not enough for paper waste. And the costs that came with setting up his own bins was the most limiting factor for him in deciding to separate waste. He also stated that the size of the studio was a limiting factor.

Recycle Materials, Interviewee 3

Interviewee 3 stated he has a very strong motivation to separate his waste and that he will do it wherever he lives, as long as it is facilitated by the municipality. He stated that he separated all waste except for organic waste. He mentioned that this is not possible in this building. However, it is possible but the bin for organic waste collection is small and hidden behind other bins. For him it is a low effort to separate waste as the waste collection is near to his house, he estimated it to be 50m. He also mentioned having learned how to do it from other people, which might result in a wrong practice.

Recycle Materials, Interviewee 5 & 6

Interviewee 5 and 6 sketch the same situation. They do not separate waste because the degree of capability and opportunity are too low. The collection point is considered to be too far away and no one is telling them to recycle or how to do it. Also the degree of opportunity at home is considered too low as the small studio does not easily allow for multiple bins to separate waste. The fact that the waste collection point is in the opposite direction of where they usually go makes it inconvenient and all these factors combined make them unmotivated to recycle.
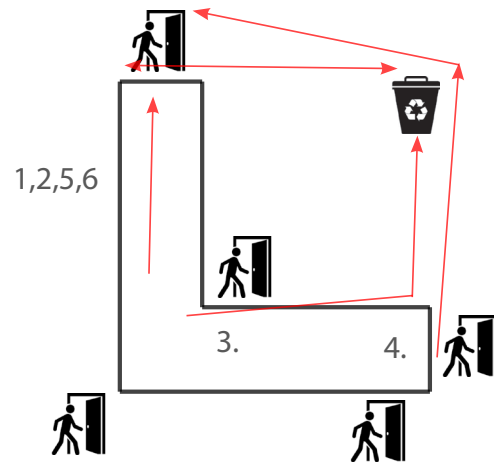

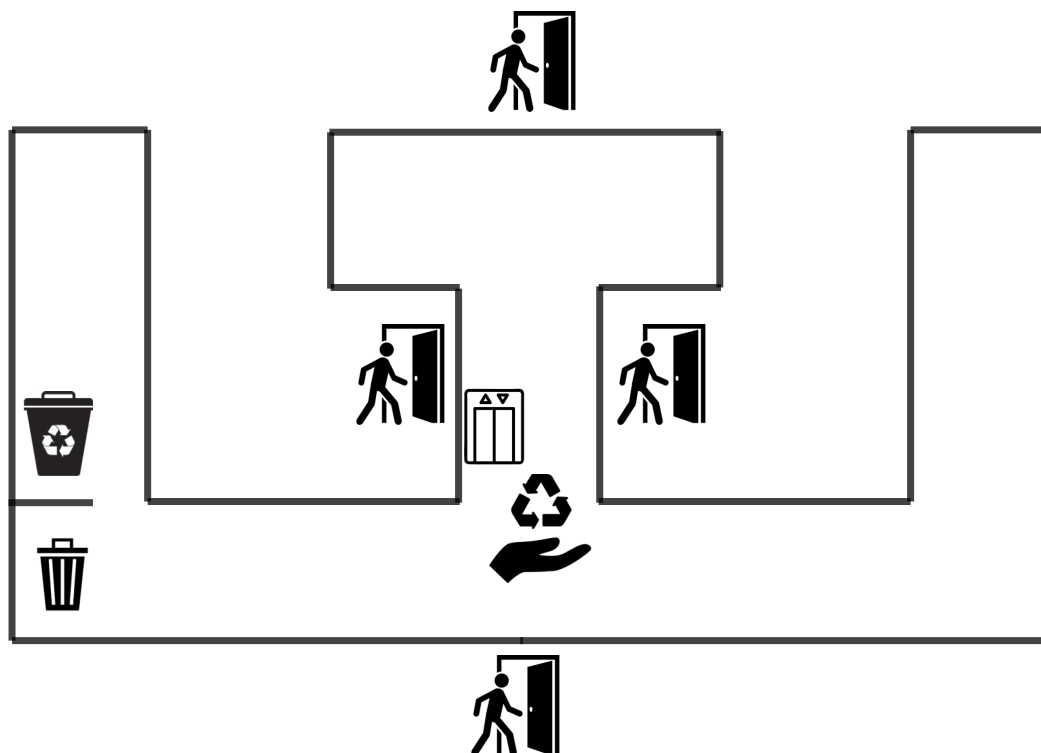Figure 19: Walking routes for Recycle Materials for Case A

4.2 Case B

Figure 20: Schematic floorplan of Case B

Year built	around 2010
Number of inhabitants	Approximately 300
Type of housing	Studios and group housing
Reason for inclusion	Mix of renovation and newly built. Gallery layout and mix of housing types

Part 1 - context research

General information

Case B was built around 2010. The complex houses around 300 people. The majority of the residents have their own studio. There are, however, a number of group houses, primarily for international students. The complex is partially newly built, and part renovated. The old part used to function as a school building.

Main Features:

The design of the complex has an E-shape with inner courtyards. The building has multiple entrances and staircases. There is an elevator at the center of the building near the main entrance linked to the gallery that connects all housing. There are two inner courtyards. There are mostly single person studios of around 26m2, but there are also a few bigger grouped housing apartments. The bigger apartments share the kitchen and bathroom, but every person has their own bedroom.

The shared facilities are located on the ground floor, and there are two bicycle storages in the basement. On the ground floor there are: postboxes, waste collection, bicycle storage, room for the facility manager, laundry room, and parking spaces. The minimum and maximum distance to the waste facility is 45m 125m.

Special features:

On the inside of the courtyard, all studios have large windows on both sides which gives connection to the other residents on the inner side of the courtyards. The gallery connects all housing and the glass elevator also gives the feeling of connection to all people living there.

Organization for Reuse/Resell:

As this complex is owned by the same housing association as Case A, the organization for Reuse/Resell is similar.

When moving out, the housing association states that it is possible for the tenant that is leaving to make his own arrangements with the new tenant about any items that could be taken over. An example would be to sell the floor to the new tenant, or a fridge, couch, lamp. But it is the responsibility of the tenant to arrange this handing over of items to the new tenant. The housing association offers a handover form on their website to help facilitate this process. In this document it is clearly stated that the new owner understands that it is his responsibility to get rid of the items when he moves out when the new tenant does not want the taken over items. The housing association also allows for students to mention what items they have that could be taken over on the advertisement of the room. This way, the new tenants already know that there are items
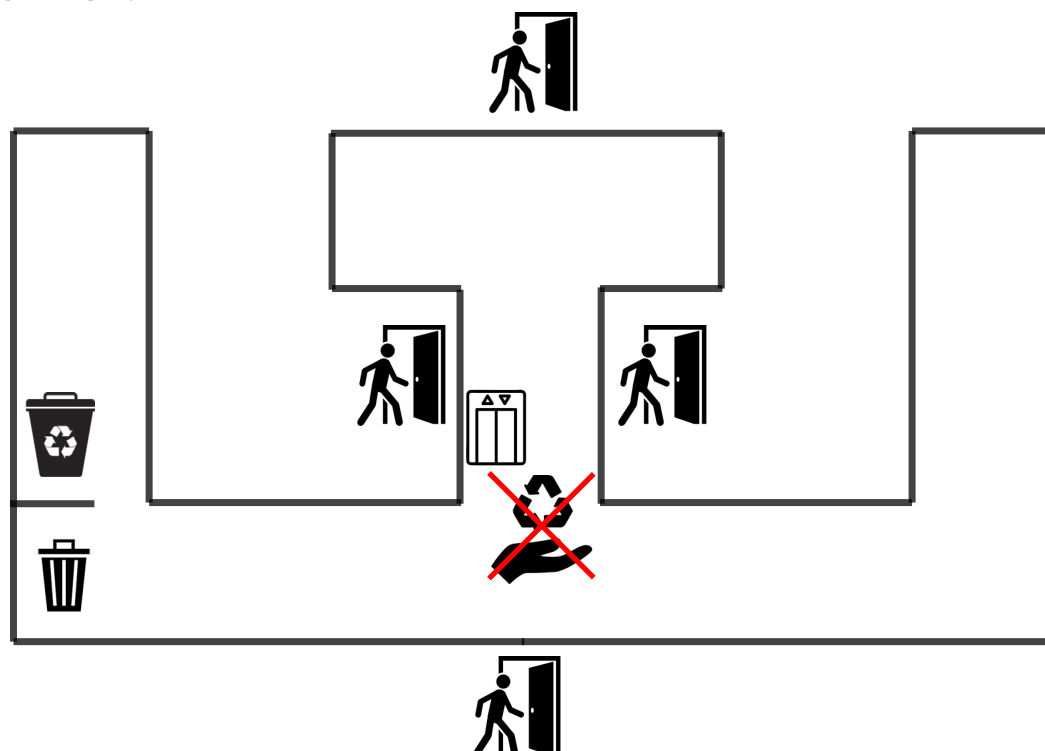

Figure 21: Schematic analysis of ground floor, multiple entrances and location of prohibited reuse and waste collection for Case B

that can be taken over.

Organization for Recycle materials:

The building facilitates a waste collection point at the bottom left of figure 21. The distance toward this point is 45m and the maximum is 125m. Out of the available bins for waste collection, 2 are dedicated to plastic, 1,5 for paper, 1 for glass and 6 for rest. On the website of the housing association, information can be found on what waste goes where, and where to find containers that are not in your building.

Preliminary COM-B aspect findings

Based on this context research, the preliminary framework can be filled in for both behaviours. In the paragraphs below, a short explanation for the aspects is given on the aspects from table 18 & 19. A green marking indicates a positive influence on the aspect, a yellow marking a positive and negative one, and red is a negative influence. If left blank, no information regarding the aspects has been found and is to be found with interviews.

Reuse:

For the physical capability of Reuse an elevator makes it easier to transport heavy objects through the building. The psychological capability is influenced by the housing association by providing a service that allows tenants to contact new or old tenants to sell or give objects for reuse.

The physical opportunity is given by this same service that allows the users to place objects on the website for reuse. This also shortens the duration of finding someone that might want to reuse the objects. The use of this service is free. However, it is prohibited to offer objects in the entrance hall for reuse, this might lead to costs that are paid for collectively by the residents of the building. Therefore, the influence is mixed for those aspects. No aspects have been found that influences motivation, so this requires more research.

Recycle materials:

For physical capability only the distance and obstacles on the way are measured. The distance to the garbage collection point is between 45m and 125m. This is marked yellow as 45m is a much shorter distance than 125m. So depending on where you live in the building, a user could have a positive or negative influence on their physical capability.

COM-B subcategory	Design aspect for Reuse	Choice technique	Case B
Capability physical	Difficulty	B2	Present
	Proximity	B1,B2	-
	Elevator	B2	Present
Capability psychological	Explain how	A2	When moving
	Reminders at waste collection	C1	-
	Clear rules	A2	When moving
	Visible	A2	-
Opportunity physical	Place to offer items	B1, B3	Advertisement
	Short process and short distance	B2	Present
	low cost or free	B2	Free for advertisement, collective cost for entrance hall
Opportunity social	People participate collectively	A3	-
	It is allowed by the organisation	B4,C2	When moving yes, in building prohibited
	Make culture visible	A2, C2	When moving
	Stimulate culture of reuse	A3,C2	When moving
Motivation reflective	Provide information on impact of reuse	A1,A2,B4	-
	Important factors that influence motivation	Depends	-
	Visible	C1,A2	-
	Thresholds	B1,B2,B4	-
Motivation automatic	Trigger for reuse on the route to garbage collection point	A1,C1	-
	Offer direct reward for reuse	B4	-
	New location allows for new habits to form	B1	-

Table 17: Findings of document analysis in the analytical framework for Reuse in Case B

COM-B subcategory	Aspect for Recycle materials	Choice technique	Case B
Capability physical	Accesibility	B2	Present
Capability psychological	Inform about what goes where	A1,A2,B2	On website
	Reminders to do it	C1	-
Opportunity physical	Distance to bins	B2	45-125m
	Different bins at home	B1,B2,B3	-
	Different bins at the collection point	B1,B2,B3	Present
	Take away the costs such as buy your own bins	B2	-
Opportunity social	People participate collectively	A3,B4,C2	-
	Visible culture	A2, C2	-
Motivation reflective	Provide information on impact of recycling materials	A2, B4	-
	Important factors that influence motivation	Depends	-
	Reward or punish behaviour	B4	-
Motivation automatic	New location allows for new habits to form	B1	-

Table 18: Findings of document analysis in the analytical framework for Recycle Materials for Case B

The psychological capability could be influenced by the provided information on the website of the housing association on how to separate waste and where to find the bins. The building provides multiple bins for paper, glass, PMD, and rest waste, so this has a positive influence on the physical opportunity. There is not a bin for organic waste. However, no data is found on whether there are bins at the homes as well.

For all the other aspects, no data has been found and requires more research. Therefore the second part of the case study is performed.

Case study part 2: User research

Based on the different aspects of table 17 & 18, interview questions will be made to research if these aspects are perceived as hypothesized. The interviews will also explore if there are other factors at play that might influence the behaviour and are then categorised according to the behaviour model and added to the framework. For the new factors, suitable choice architecture techniques will be recommended. The interview protocol used can be found in appendix D.

Reuse

Findings Reuse Interviews

The findings that are presented in table 19 are explained in detail per COM-B subcategory in the section below.

The physical capability of all the interviewees was positive. No interviewee stated that they were incapable of reusing because of any aspect. None of the interviewees mentioned that the elevator is helpful in regard to reuse. Interviewee 11 mentioned that there is a trolley available which makes it easier to move large and heavy items in the horizontal plane.

The findings regarding psychological capability were mixed. When moving all interviewees were able to take over items from previous tenants, except for interviewee 8 it was not clear that it was possible. However, interviewee 8 moved into one of the grouped housing unit and stated the room was already furnished. The already furnished room is a way of forcing reuse. Interviewee 8 did state that he would have liked to take over items from the previous owner that are not part of the furnished room. All interviewees stated that there are no clear rules when offering items at the entrance hall. Interviewee 7 stated that people misuse the space by offering things that should be regarded as trash such as a dirty old matras. She also stated that she might hold higher standards than other people to what is reusable and what is not. Therefore it is not clear which items you should and which you shouldn't offer. Interviewee 8 stated that sometimes people put a note on the item that is offered stating it is free to take. This makes it clear that you can take it, but it is not common practice. Because this place is frequently used, it is a visible location that informs people that they can put their items here to offer for reuse.

The physical opportunity is regarded as positive by interviewees. There are multiple locations to offer items for reuse. All interviewees mentioned that people offer stuff in the entrance hall, marked with a handover symbol in figure 21. The residents are also active on the facebookgroup of the building, and on the advertisement of the housing association when they move out. Interviewee 7 and 10 also mentioned another spot to offer items next to the waste collection. There is also a spot at the waste collection point for large objects that don't fit the bins. Interviewee 7 stated that she took some pots from this location. Interviewee 12 stated that he took a microwave from the same location. All interviewees stated that the location at the entrance hall is very convenient in terms of reuse. The items at the entrance hall are free, and there is a short process and distance because it is within the building and on the way.

In terms of social opportunity, the housing association aids in reuse for when people move in and out. All interviewees stated this except for interviewee 8. However, the placing of items at the entrance is prohibited by the housing association. There is a small sign stating that if people offer items for free it will be charged as service costs for the entire building, but people still offer items for free at the entrance hall.

For reflective motivation the following reasons were mentioned as factors to reuse. Interviewee 7 stated that she mainly does it for environmental reasons. Also that she prefers to buy a new refrigerator or washing machine that consumes less energy than reusing a very old one that uses way more energy. She considers that to be more sustainable. The fact that items are cheap or free is also a reason for the interviewees to reuse because of their limited budget and low income. Sometimes an item is offered that they need and therefore they take it. The quality of the item is also an important factor.

For automatic motivation no factors were stated. This might be because of the complexity and non repetitive nature of the behaviour. However, all interviewees did mention they would offer items here if they regard it as reusable and don't want money for it. They all have to pass the entrance hall when entering the building, triggering them to reuse when something is offered. And when they

COM-B aspect	Design aspect for Reuse	Choice technique	Case B
Capability physical	Difficulty	B2	Easy, trolley
	Proximity	B1,B2	Central location
	Elevator	B2	Present
Capability psychological	Explain how	A2	Advertisement, vague for entrance
	Reminders at waste collection	C1	Option to offer potential reuse next to waste collection
	Clear rules	A2	Prohibited, but people do it anyways, drop-off
	Visible	A2	prohibited, but visible
	Awareness of digital platform	A2	present
	Note that you can take it	A2	Sometimes
Opportunity physical	Place to offer items	B1, B3	Advertisement, Entrance but not clear
	Short process and short distance	B2	present, at the entrance
	low cost or free	B2	joint costs, free placing
	Advertisement for next tenant	A2,C1	Present
Opportunity social	People participate collectively	A3	Present
	It is allowed by the organisation	B4,C2	When moving, but prohibited at entrace, but people do it anyways
	Make culture visible	A2, C2	Present
	Contact with previous and next tenants	A2	Present
Motivation reflective	Provide information on impact of reuse	A1,A2,B4	Missing
	Make it visible	C1,A2	Present
	Low costs	B2	Present
	Hygiene	-	Depends on item
	Convenience	B2	Present
	Moving to studio needs more things	B1,B3	Present
	Good quality items	-	Depends on person and object
Motivation automatic	Trigger for reuse on the route to garbage collection point	A1,C1	Present
	Offer direct reward for reuse	B4	Missing
	New location allows for new habits to form	B1	Present

Table 19: Findings of interviews in the analytical framework for Reuse in Case B

are going to the trash collection point they also pass by the entrance hall, so this might trigger them to offer it for free first.

Mapping influence of design on behaviour

Based on the findings of the interviews following the different subcategories of the COM-B model, a sort of customer journey can be made for every interviewee on how they experience the design of the building in showing their behaviour. Based on all different experiences of the interviewees, the influence of design on different main categories of the COM-B model are presented for Reuse/Resell. In figure 22 the design principles that influenced them are shown per COM-B category. Figure 23 shows the different walking routes of the interviewees.

Reuse Interviewee 7-12

All interviewees mentioned how the convenience of the location influences them to show reuse behaviour. They all walk past it when they enter the building, making it visible and on the way to their
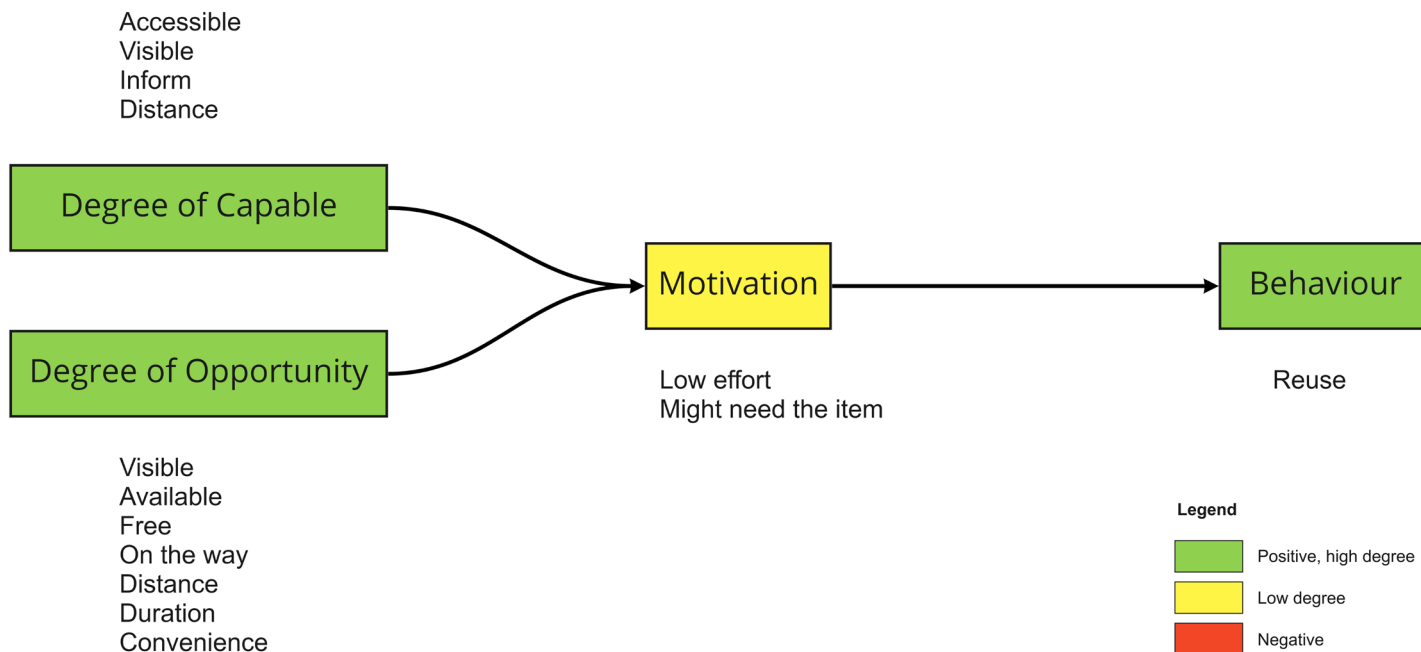
Figure 22: The design aspects that influence behaviour mapped in order according to the COM-B model for Reuse for Case B

home. The degree of capability and opportunity are so high, that the only thing that stops them from reusing is the quality of the product, whether they need it and the hygiene factor. Also when offering items, sometimes they prefer to have money, but if they cant sell it, it offered for free at the location.

Figure 23: Walking routes of interviewees for Reuse in the building at Case B

Recycle Materials

Findings Recycle interviews

The findings that are presented in table 20 are explained in detail per COM-B subcategory in the section below.

For physical capability no aspects that affect it have been found other than the positive influence of the elevator and that the waste facility is accessible.

For psychological capability however, it is not clear. During the interviews it has been stated by all interviewees that they mostly learned how to separate waste from other people. They have never been properly informed as to what goes where so when going into detail about separating waste it becomes clear that are not properly informed on the right practice. Interviewee 8 stated that in his grouped housing, it was already common practice to separate waste, and that his roommates told him what waste goes in what bin. Interviewee 8 and 10 mentioned that it is difficult for them to understand from the packaging what goes where as most information is in Dutch and they don't speak the language. The waste collection room for waste separation is hidden in a separate room next to the collection point for rest waste, but the interviewees did know about the location.
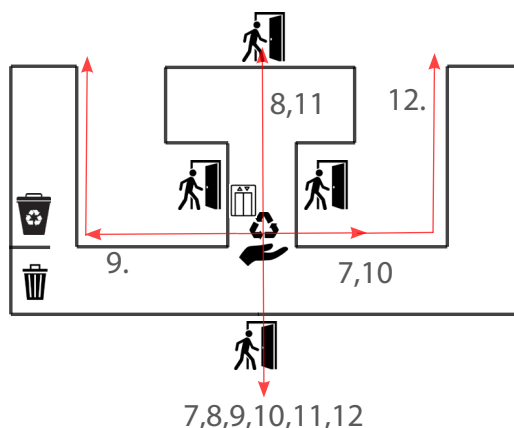
The physical opportunity is positive for separating paper, glass, PMD and rest waste. Interviewee 7 stated that she would like to also separate organic waste, but that the building does not facilitate this. She also mentioned that she does know of a collection point that is near the building, but considers it to be too far away. After the interview a distance of 175m from the entrance of the building was measured. Interviewees 9 and 10 stated that the waste collection point is very convenient compared to the situation in the city centre where they lived before. In this building they can offer their waste whenever they want, but in the city centre they could only offer their paper waste once every two

COM-B aspect	Design aspect for Recycle Materials	Choice technique	Case B
Capability physical	Accesibility	B2	Present
	Elevator	B2	Present
Capability psychological	Inform about what goes where	A1,A2,B2	Roommates, other people
	Reminders to do it	C1	There are bins to separate at the collection point
	Visible	C1,A2	In a seperate room that is hidden
Opportunity physical	Distance to bins	B2	45m-125m
	Different bins at home	B1,B2,B3	In group housing yes, studio missing, small studio lacks space
	Different bins at the collection point	B1,B2,B3	Present, but hidden
	Take away the costs such as buy your own bins	B2	Missing
	Capacity bins for building	B2	Glass
	Size of studio	B2	Too small
Opportunity social	People participate collectively	A3,B4,C2	Present
	Visible culture	A2, C2	Collection point hidden
Motivation reflective	Provide information on impact of recycling materials	A2, B4	Missing
	Reward or punish behaviour	B4	Missing
	Convenience	B2	Bins always available
	Stinking bins	B4	Not mentioned
	Not wanting to put effort	B2	Not separating all waste
	No one is forcing	A3,C2	Unclear
	Roommates do it	A3	For group housing
	Environmental reasons	A2	For most interviewees
Motivation automatic	New location allows for new habits to form	B1	Present

Table 20: Findings of interviews in the analytical framework for Recycle Materials in Case B

weeks on a single morning, making it much more difficult for them to do it. Interviewee 10 also stated that in order to separate waste he had to cycle a long distance to a proper bin. This factor caused him to not separate waste in the city centre, but he does do it in this building. Interviewee 10 stated that the capacity for glass waste is not always sufficient, and that the bin is missing sometimes. Interviewees 7, 9, 10 and 12 mentioned that they made their own separate bins in their own studio. Interviewee 9 stated that he uses bags instead of bins because of the small area of the studio. For interviewees 8 and 11 the bins for separated waste collection were already in place when they moved in to their grouped housing.

For the social opportunity, the interviewees were asked about participation of neighbours in separating waste. All interviewees responded that they didn't really know. Interviewee 7 had four friends living in the building, three of them did separate waste. Interviewee 9 said to never have received any information from the housing association about waste separation. Interviewee 10 stated that when he looks at the waste collection point, it is clear that some people put more effort in it then others. Interviewee 9 stated that in a previous building he lived it was more obvious that neighbours separate waste because there would be a clear overview of the bins. In this building the rest waste collection is more visible and convenient then the room that is next to it for waste separation. He stated that most people use the rest bins. Interviewee 11 stated that in his househould, the roommates keep each other accountable when they see someone is not separating waste properly.

For reflective motivation interviewee 8 stated that he does it because it is the system of his household, they do it, so he does it too. Interviewee 9 stated to always have separated waste and that it was part of his upbringing, but that he does it more now he lives in this building due to the convenience of having always available bins. Interviewee 10 stated that the convenience also helps him to separate waste in the building. Interviewee 7 mentioned that she stopped separating plastic waste because of a podcast that stated that all plastic from the Netherlands is shipped to Turkey and ends up in a landfill over there. So she prefers it to be incinerated so it won't do any harm elsewhere. Interviewee 7, 9 and 10 stated that they separate waste because of environmental reasons.

The automatic motivation didn't come up during the interviews.

Mapping influence of design on behaviour

Based on the findings of the interviews following the different subcategories of the COM-B model, a sort of customer journey can be made for every interviewee on how they experience the design of the building in showing their behaviour. Based on all different experiences of the interviewees, the influence of design on different main categories of the COM-B model are presented for Recycle Materials. In figure 24 the design principles that influenced them are shown per COM-B category. In figure 25 the different walking routes of the interviewees are presented.

Recycle Materials, Interviewee 7

Interviewee 7 mentioned that she is very motivated to separate waste for environmental reasons. There is a clear rationale in why she separates waste. She does not separate PMD because she learned from a podcast that the plastic gets shipped to a different country where it ends up in a landfill. Therefore she stopped separating waste, as she thinks it is more sustainable for the planet if the plastic gets incinerated instead of ending up in a landfill. However, she would like to separate organic waste, but she is not provided the opportunity in the building. There is the opportunity to offer organic waste near the building, but it is just too far away and inconvenient to do so.

Recycle Materials, Interviewee 8 & 11

Interviewee 8 and 11 live in the grouped housing in the building. They both stated that they separate waste because in their house it is common practice, and the bins to separate waste are already there. This makes it easy for them to do it. They also learned from the roommates how to separate waste.

Recycle Materials, Interviewee 9

Interviewee 9 separates his waste but does state that the building is not very helpful. He said to separate waste wherever he lives so that the materials can be easily recycled. The size of his studio makes it difficult for him to make room for different bins. He solved this problem by using bags instead of bins, but mentioned that extra space for bins would be nice. He also stated that the waste facility for separating is quite hidden and that this does not stimulate neighbours to separate waste. He didn't know where he learned how to separate waste, he thought from his parents. So it is possible that he ends up doing it a bit wrong as he doesnt know precisely what items go where. The constant availability of the bins at the collection point do make it convenient for him to separate waste. When he lived in the city centre he had a more difficult time to offer his separated waste as he could only offer it once every week or two weeks.
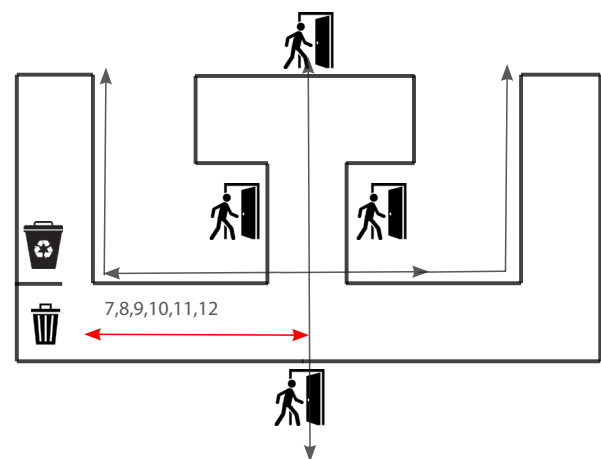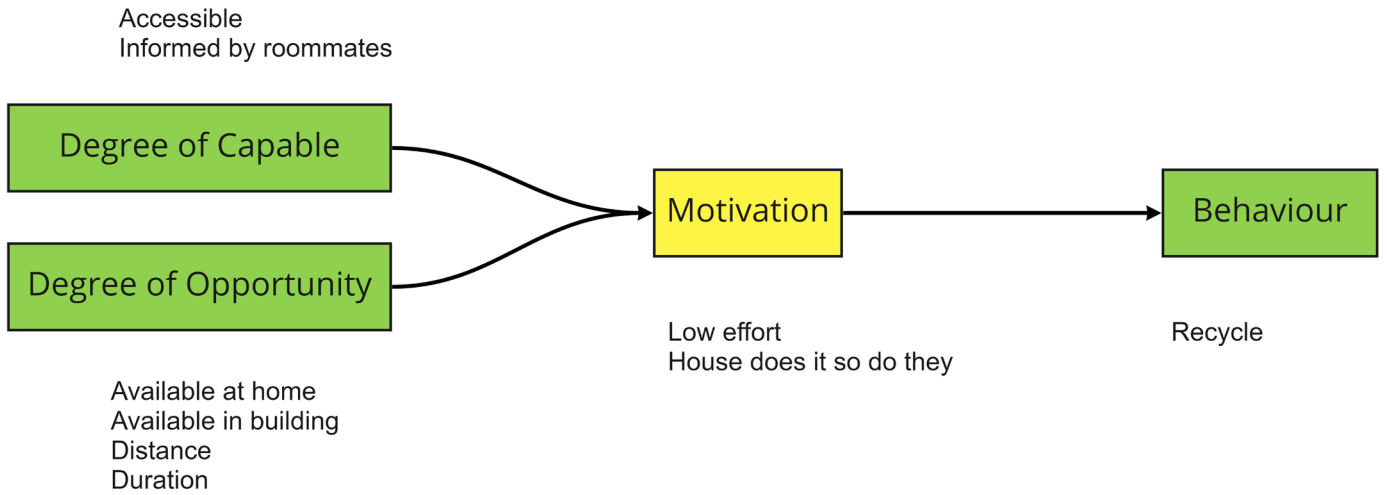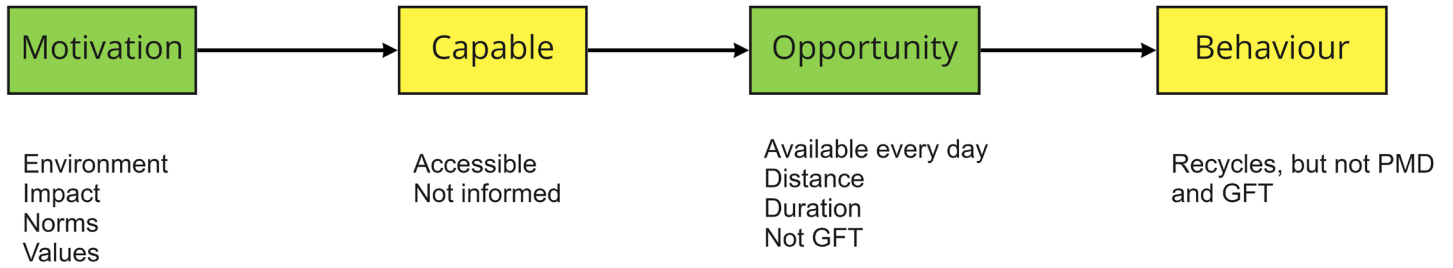
7,8,9,10,11,12

Figure 25: Walking routes for Recycle Materials for Case B

Interviewee 8 & 11 Recycle

Accessible
Informed by roommates

| Degree of Capable |
| Degree of Opportunity |

Motivation

Behaviour

Low effort
House does it so do they

Recycle

Available at home
Available in building
Distance
Duration

Interviewee 7 Recycle

Motivation → Capable → Opportunity → Behaviour

Environment
Impact
Norms
Values

Accessible
Not informed

Available every day
Distance
Duration
Not GFT

Recycles, but not PMD
and GFT

Interviewee 9 Recycle

Motivation → Capable → Opportunity → Behaviour

Environment
Impact
Norms
Values

Accessible
Not very visible
Not informed
Learned from others

Available every day
Small room difficult to
make own bins
Convenience of building

Recycles

Legend

Positive, high degree
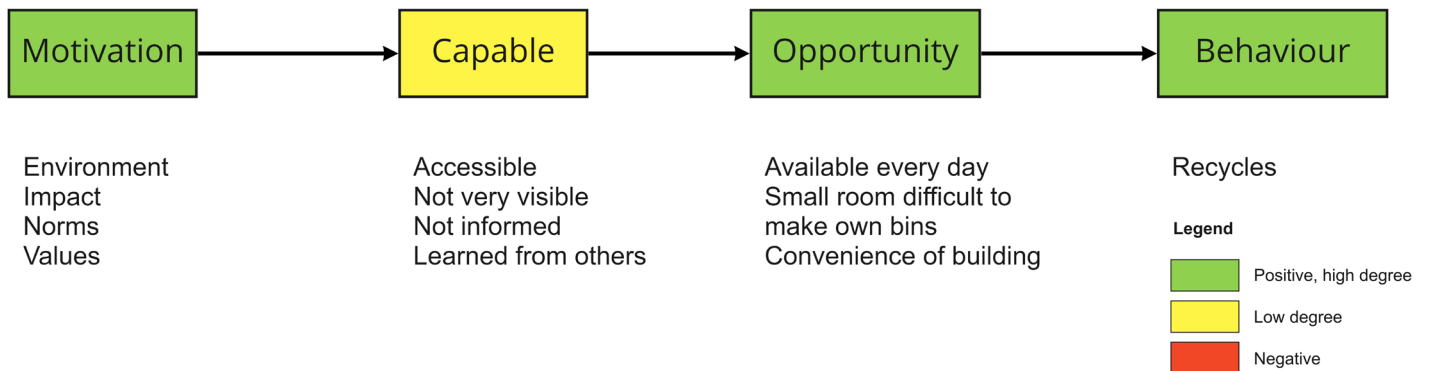Low degree
Negative

Figure 24: The design aspects that influence behaviour mapped in order according to the COM-B model for Recycle Material for Case B

4.3 Case study part 3: Cross-case analysis

When employing the framework to multiple cases, the table gains additional columns per case and the specific behaviour is studied in different cases. This allows for a quick overview of differences and similarities between cases.

In table 21 the findings for Reuse, and in table 22 the finding for Recycle Materials of both cases are presented. A lot of similarities can be found. The cases are also very similar in the design. The similarities and differences will be discussed per COM-B aspect per behaviour. After the comparison of the findings in the framework, the different customer journeys are compared.

Cross Case Reuse

Looking at table 21 and the findings of the interviews the following results are found:

For physical capability in both cases none of the interviewees mentioned being unable to reuse. Both cases have an elevator in a central location of the building, which should allow for easy transportation of heavy items over multiple levels. In Case B, it is mentioned that there is a trolley that can be used for easy transportion of items in the horizontal plane. So it is easier to transport items in Case B, but the influence on the physical capability is positive in both cases.

For psychological capability, the context is also similar. The cases are from the same housing association so they have the same rules. When moving the housing association provides the possibility to advertise and get into contact with the next tenant for reselling items like floors, lamps and furniture. The offering of free items in the hallways is prohibited and can lead to increased service costs for the entire building, but people are still offering items and not all interviewees were aware of the

COM-B aspect	Design aspect for Reuse	Choice technique	Case A	Case B
Capability physical	Difficulty	B2	Easy	Easier, trolley
	Proximity	B1,B2	Central location	Central location
	Elevator	B2	Present	Present
Capability psychological	Explain how	A2	Advertisement, vague for entrance	Advertisement, vague for entrance
	Reminders at waste collection	C1	Stimulating to throw away	Option to offer potential reuse next to waste collection
	Clear rules	A2	Prohibited at entrance, but people do it anyways, drop-off, mayhem	Prohibited, but people do it anyways, drop-off
	Visible	A2	prohibited, but visible	prohibited, but visible
	Awareness of digital platform	A2	Not all interviewees know about facebook group	present
	Note that you can take it	A2	-	Sometimes
Opportunity physical	Place to offer items	B1, B3	Advertisement, Entrance but not clear	Advertisement, Entrance but not clear
	Short process and short distance	B2	present, max 75m	present, at the entrance
	low cost or free	B2	joint costs, free placing	joint costs, free placing
	Advertisement for next tenant	A2,C1	Present	Present
Opportunity social	People participate collectively	A3	Present	Present
	It is allowed by the organisation	B4,C2	When moving, but prohibited at entrace, but people do it anyways	When moving, but prohibited at entrace, but people do it anyways
	Make culture visible	A2, C2	Present	Present
	Contact with previous and next tenants	A2	Present	Present
Motivation reflective	Provide information on impact of reuse	A1,A2,B4	Missing	Missing
	Make it visible	C1,A2	Present	Present
	Low costs	B2	Present	Present
	Hygiene	-	Depends on item	Depends on item
	Convenience	B2	Present	Present
	Moving to studio needs more things	B1,B3	Present	Present
	Good quality items	-	Depends on person and object	Depends on person and object
Motivation automatic	Trigger for reuse on the route to garbage collection point	A1,C1	Depends on route	Present
	Offer direct reward for reuse	B4	Missing	Missing
	New location allows for new habits to form	B1	Present	Present

Table 21: Cross case analysis findings of both cases for Reuse

prohibition. All interviewees stated that there are no clear rules regarding the offering of free items. Because of the visible location, interviewees stated that they know something is available because they walk past it if the enter the building in Case B. For Case A, it was dependent on the location of the home, as there are multiple entrances and not every inhabitant uses the main entrance. Finally, in Case B it was mentioned that sometimes people put a note on the item in the entrance hall stating it is free to take, making it clear that you can take it. It might also happen in the other case but it was not mentioned. So the design can make it easier for the residents to know when items are offered due to the visibility caused by all residents passing by the same main entrance hall on their way home. Clear rules are still missing, so this could also be provided to increase the psychological capability.

There is the physical opportunity to offer items in the entrance hall of both cases because there is a lot of space. In Case B there were two places mentioned to offer items, but in Case A only the entrance hall was mentioned. Because of the central location most inhabitants will have a short duration of reusing items from the entrance hall. And as already mentioned, the placing of items can lead to joint costs for the inhabitants of the building, but taking the items is free. So the physical opportunity is positive for both cases. However, the degree of opportunity can be lower for some of the residents depending on how far they live from the entrance hall.

In both cases the findings of the interviews indicated that many inhabitants are active in reuse and that there is a visible culture of people offering and taking items for reuse. All but one of the interviewees stated to have taken over items from the previous tenant. The fact that it is not allowed by the organisation to offer items in the entrance hall does not stop the inhabitants from offering items. But allowing it might increase participation even more.

For reflective motivation there were similar reasons to take over items. When moving to a studio the students had to buy more things when compared to moving to a grouped housing. Because they have a low budget they want cheaper things and prefer to buy second hand items or take them over for free. The convenience of taking over from the previous tenant and taking something from the entrance hall was also mentioned as an important factor. Finally there are product dependent factors such as hygiene, quality and whether the product is needed. So the design influences motivation by the degree of capability and opportunity, but the products offered also influence the motivation to take over the product.

For automatic motivation, the interviewees stated that in other buildings there would be less reuse. This new location which has the space for offering items influenced their behaviour by triggering them when entering the building. In Case B, when throwing items away the inhabitant has to walk past the potential reuse spot, but in Case A the multiple routes do not all pass by the reuse location. So walking past the reuse location when throwing items away can trigger reuse behaviour.

Cross Case Mapping Reuse

Comparing the two cases on reuse, it is seen that for Case B all interviewees had the same experience as they all walk past the reuse location. But in Case A, there where different experiences. In figure 17 and 23 the different walking routes are displayed for
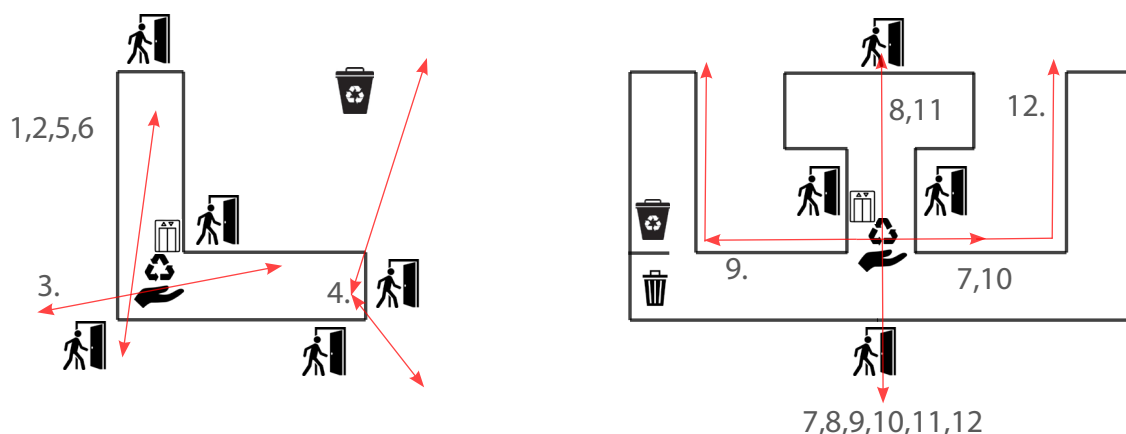

Figure 17 & 23: Walking routes of interviewees in the building for Reuse respectively Case A and Case B
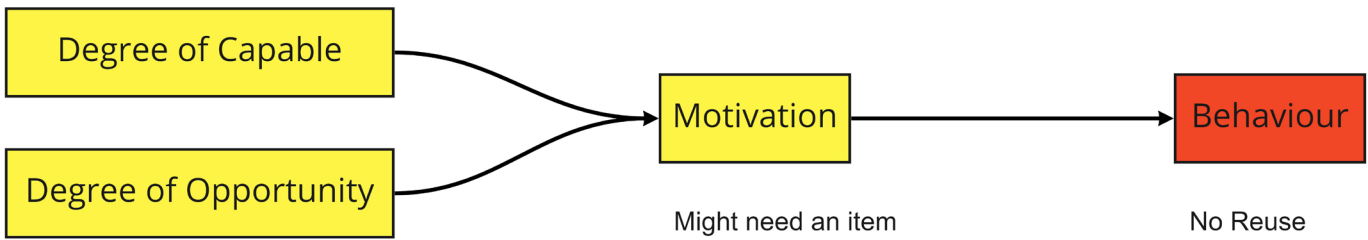
both cases. The main difference is that in Case B, the location for offering reuse is visible and on the way for every resident. If they enter the building, they will encounter the items that are offered for reuse. The elevator is next to the reuse location and there is a trolley to move items that are heavy or large. At Case A, it is dependent on which entrance you take and the route you walk. Therefore, interviewee 4 can only make use of the reuse location, if he is motivated to take the extra effort to walk to the entrance hall that he does not regularly use. If interviewee 4 lived in Case B, he might be triggered to take an item for reuse on a daily basis. In a similar way, people living in Case B could stop from reusing because they move to interviewee 4's location in Case A.

In figure 26 the differences in customer journeys is shown. Interviewee 4 is an example of an inhabitant living in Case A that has a low degree of capability and opportunity because of the location of his house. He does not pass by the main entrance hall in his daily routine which causes him to not get motivated to take something. But in Case B, every resident passes by the main entrance hall where items are offered. This difference determines whether a person gets motivated or not by the design. The other interviewees for Case A experienced the same influence of the interviewees living in Case B, causing them to reuse more than interviewee 4.

Case A:

Interviewee 4 Reuse

Accessible
Not directly visible
Not known when available

```
┌─────────────────────┐
│  Degree of Capable  │
└─────────────────────┘            ┌──────────────┐          ┌──────────────┐
                          ──────▶  │  Motivation  │ ──────▶  │  Behaviour   │
┌─────────────────────┐            └──────────────┘          └──────────────┘
│ Degree of Opportunity│
└─────────────────────┘           Might need an item            No Reuse
```
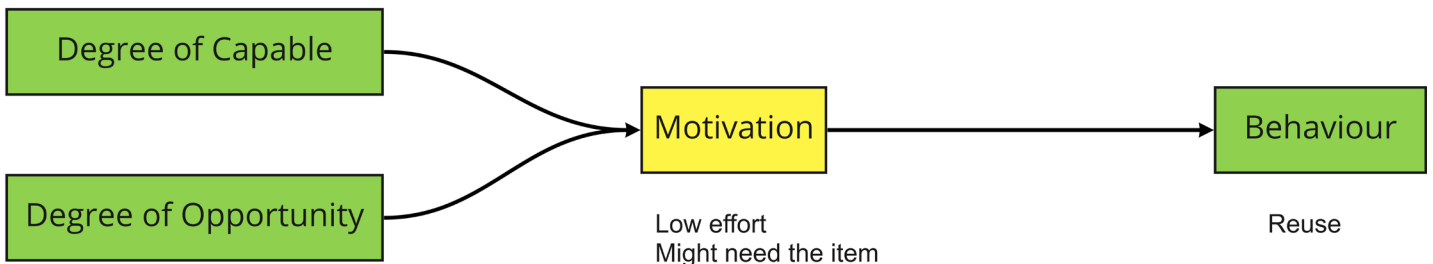
Available but not directly visible
Unknown when available
Free
Not on the way
Not very convenient

Case B:

Interviewees 7-12 Reuse

Accessible
Visible
Inform
Distance

```
┌─────────────────────┐
│  Degree of Capable  │
└─────────────────────┘            ┌──────────────┐          ┌──────────────┐
                          ──────▶  │  Motivation  │ ──────▶  │  Behaviour   │
┌─────────────────────┐            └──────────────┘          └──────────────┘
│ Degree of Opportunity│
└─────────────────────┘           Low effort                   Reuse
                                  Might need the item
```

Visible
Available
Free
On the way
Distance
Duration
Convenience

Legend

🟩	Positive, high degree
🟨	Low degree
🟥	Negative

Figure 26: The design aspects that influence behaviour mapped in order according to the COM-B model for both cases for Reuse

COM-B aspect	Design aspect for Recycle Materials	Choice technique	Case A	Case B
Capability physical	Accesibility	B2	Present	Present
	Elevator	B2	Present	Present
Capability psychological	Inform about what goes where	A1,A2,B2	Other people	Roommates, other people
	Reminders to do it	C1	There are bins to separate at the collection point	There are bins to separate at the collection point
	Visible	C1,A2	Present	In a seperate room that is hidden
Opportunity physical	Distance to bins	B2	50-90m	45m-125m
	Different bins at home	B1,B2,B3	Not standard, small studio lacks space	In group housing yes, studio missing, small studio lacks space
	Different bins at the collection point	B1,B2,B3	Present	Present, but hidden
	Take away the costs such as buy your own bins	B2	Missing	Missing
	Capacity bins for building	B2	Paper	Glass
	Size of studio	B2	Too small	Too small
Opportunity social	People participate collectively	A3,B4,C2	present, not properly, collection point neglected	Present
	Visible culture	A2, C2	Present, collection point out in the open	Collection point hidden
Motivation reflective	Provide information on impact of recycling materials	A2, B4	Missing	Missing
	Reward or punish behaviour	B4	Missing	Missing
	Convenience	B2	Depends on location	Bins always available
	Stinking bins	B4	For some interviewees	Not mentioned
	Not wanting to put effort	B2	For some interviewees	Not separating all waste
	No one is forcing	A3,C2	No control	Unclear
	Roommates do it	A3	-	For group housing
	Environmental reasons	A2	For most interviewees	For most interviewees
Motivation automatic	New location allows for new habits to form	B1	Present	Present

Table 22: Cross case analysis findings of both cases for Recycle Materials

Cross Case Recycle Materials

Looking at table 22 and the findings of the interviews the following results are found:

The physical capability was positive in both cases. None of the interviewees mentioned that they were not physically capable of recycling materials.

However, the psychological capability is not positive for all interviewees. Even the ones that were separating waste did not know the proper rules for recycling. For both cases the interviewees were not aware of the proper information on how to recycle materials. The interviewees stated that they mostly learned how to do it from people they know or do it intuitively. Figures 19 and 25 show the location of the waste collection facility of both cases. At Case A the waste collection facility has all bins together, so the inhabitants are reminded that they can separate waste. At Case B, the waste separation bins are in a separate room from the rest of the waste. So people are not always reminded to separate their waste, nor are they properly informed on how to do.
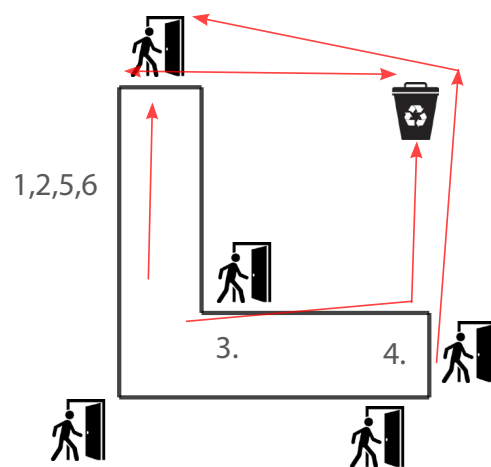

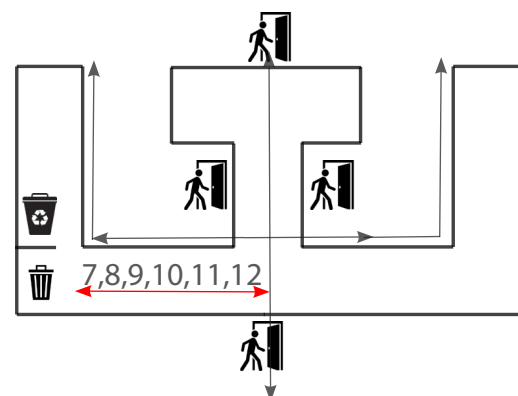Figure 19: Walking routes for Recycle Materials in Case A

Figure 25: Walking routes for Recycle Materials for Case B

The physical opportunity in the buildings is viewed in a mixed way, but mosly negative or with a low degree. Both cases offer bins for collecting paper, glass, PMD and rest. Case A also has a bin for organic waste. The capacity was not enough for paper for Case A, and Case B had issues with capacity for glass. In figures 19 & 25 the different walking routes of the interviewees can be seen for both cases. For Case A, interviewee 4 stated that the waste collection point is very close to his house and on the way to his daily trip to the supermarket. Other interviewees from the same case stated how it is so far away and in the opposite direction of where they have to go. For Case B the distance was not mentioned as a problem by most interviewees. Only interviewee 12 stated that it is far away, but he also has to longest possible distance from the waste collection to his studio. In Case B, every residence has to walk a bit away from the main entrance, but can make it part of the journey of leaving the building. So having the waste collection on the way for all residents or near it, is a way of positively influencing their degree of opportunity.

All interviewees from both cases stated that they have to make their own bins for collecting their waste at home. Only the interviewees living in grouped housing stated that the waste collection bins for separating were already present when they moved in. For some interviewees, the studio was regarded as too small to create several bins for waste separation, and the effort and costs connected to it were too much. So providing bins in the housing would be an effective way of increasing the physical opportunity in these cases.

The social opportunity was also mixed. For Case A, the waste collection point is out in the open and visible to everyone. This makes the culture that exists in recycling materials visible. However, the waste collection point is often dirty and people do not separate their waste properly. In Case B, the waste collection point is hidden in a room separate from the rest waste collection, making it only visible for people that separate waste. So making the waste collection visible can have a positive influence on the capability, but might have a negative influence on the social opportunity if it is neglected or dirty.

One of the reflective motivations for the interviewees to recycle materials was for environmental reasons. So that the materials are easier to recycle, and to have a lower impact on the environment. There were also interviewees that are not convinced of the functioning of the recycling facilities and therefore do not separate certain waste. In both cases the convenience of having the bins available at all times was mentioned. But the effort to start separating waste was perceived as high. The interviewees living in the group housing stated that they separate waste because their roommates do it. So the high degree of capability and opportunity makes interviewees show the behaviour, but also informing them on the impacts and importance of the behaviour can be beneficial as they are not yet informed.

For automatic motivation no aspects have been found.

Cross Case Mapping Recycle Materials

In figure 27 the differences in customer journeys is shown. The different walking routes are presented in figures 19 & 25. The waste collection point of Case A is such that all bins for separation are visible and near each other. The location makes it inconvenient for some and convenient for others, as some go past the waste collection on their daily trip, and others have to go out of their way to throw away the trash. Interviewee 4 stated that for him it is very convenient as he passes by the collection point when he goes away from home. In Case B, the distance to the waste collection is more equal, as it is not directly on the way for all residents, but fairly close to the entrance hall. It might be that if they live in Case A that they would stop from separating waste if it is no longer on the way. The waste collection point for Case B is segrated. The rest waste collection is visible, but the separated waste is hidden in a room next to it. This makes it so that people are not reminded to separate waste and requires a bit extra effort when they do separate waste. If interviewee 2 lived in Case B, he might have not been aware of the possibility to separate waste. Or at least it would have taken longer to realise that it is possible. Making it more difficult for him to show the behaviour.

Another difference in the cases is that in Case B the organic waste is not collected on a building level. Interviewee 7 stated that she would like to do it, but doesn't because the distance to the neighbourhood organic waste collection point is too big. If she lived in Case A, it is likely that she would separate organic waste as it is collected next to all other bins. So by providing a waste collection facility that collects all trash increases the degree of opportunity.
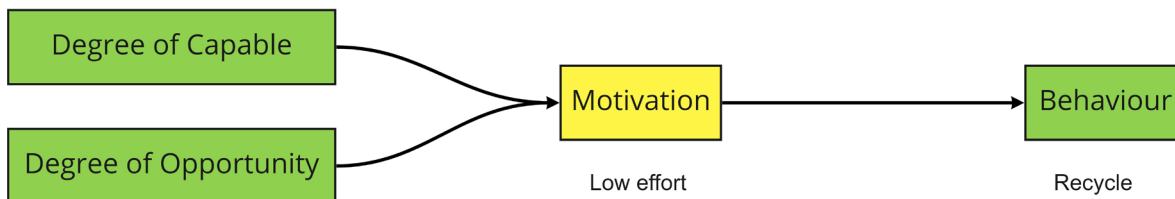
In both cases it was stated that the interviewees had to put up their own bins to start separating waste. The interviewees stated that the size of the studio makes it more difficult for them to make room for several bins. In the group housing the bins were already available in their house and this influenced the interviewees in a positive way to separate waste. So by providing bins in the design of the studio would increase the degree of opportunity for the inhabitants.

Some interviewees had a strong motivation to separate waste due to pro-environmental values. While others are motivated by the context which makes it easy for them to separate wate. There were also interviewees that were demotivated to separate waste due to the low degree of capability and opportunity, or because they do not believe in the impact of separating waste.
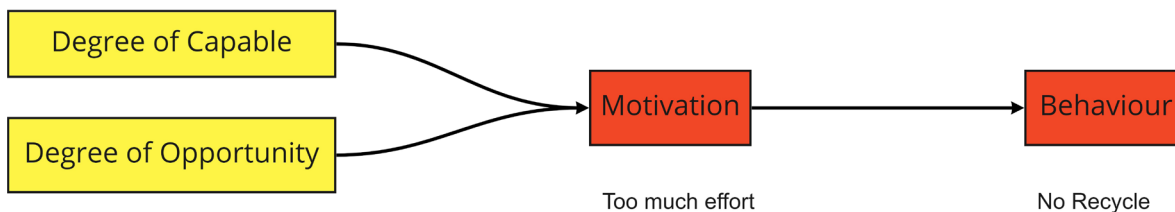
Case A:

Interviewee 2 Recycle

Accessible
Inform
Visible

| Degree of Capable |
| Degree of Opportunity | → | Motivation | → | Behaviour |

Low effort

Recycle

Available
Capacity
Distance
Duration
Costs
Size of studio

Interviewee 5 & 6 Recycle

Accessible
Not informed
Visible
Distance is too far

| Degree of Capable |
| Degree of Opportunity | → | Motivation | → | Behaviour |

Too much effort

No Recycle

Available at collection
Not available at home
Distance is too far
It is not convenient
It is not on the way
Size of studio

Case B:

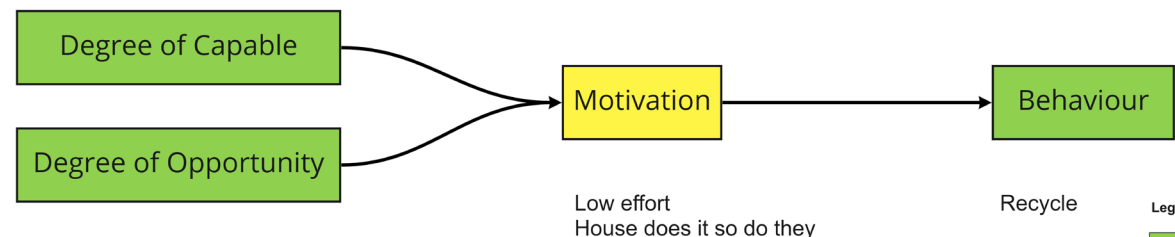**Interviewee 7 Recycle**
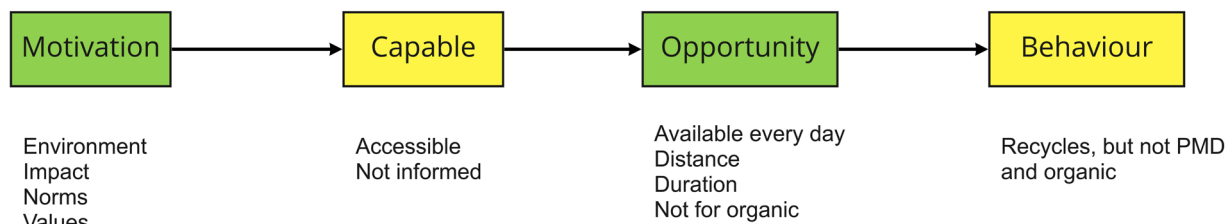
| Motivation | → | Capable | → | Opportunity | → | Behaviour |

Environment
Impact
Norms
Values

Accessible
Not informed

Available every day
Distance
Duration
Not for organic

Recycles, but not PMD
and organic

Interviewee 8 & 11 Recycle

Accessible
Informed by roommates

| Degree of Capable |
| Degree of Opportunity | → | Motivation | → | Behaviour |

Low effort
House does it so do they

Recycle

Available at home
Available in building
Distance
Duration

Legend

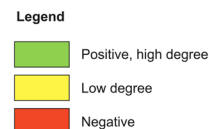- 🟩 Positive, high degree
- 🟨 Low degree
- 🟥 Negative

Figure 27: The design aspects that influence behaviour mapped in order according to the COM-B model for both cases for Recycle Materials

4.4 Summary of syntheses

In this section the syntheses of the case studies will be summarized into one concluding chapter. The syntheses are structured per COM-B sub category and per behaviour and are distilled from the cross case analysis.

Reuse:

Physical capability Reuse
The physical capability was deemed positive in both cases due to the elevator and short distances. The degree of capability was higher in Case B due to the presence of a trolley.

Psychological capability Reuse
In both cases, clear rules are missing for offering items in the entrance hall, even though it is prohibited by the housing association. People still show reuse behaviour but it is not always clear how to do it. The design is such that the residents know when items are offered due to the visibility caused by passing by the main entrance hall on their way home. However, if residents take a different route that does not pass the main entrance hall, they can not know an item is being offered.

Physical opportunity Reuse
The physical opportunity is positive for both cases due to the short duration, nearby location, and free items. However, the degree of opportunity can be lower for some of the residents depending on how far they live from the entrance hall.

Social opportunity Reuse
The fact that it is not allowed by the organisation to offer items in the entrance hall does not stop the inhabitants from offering items. But allowing it might increase participation even more. When moving it is stimulated by the organisation to reuse from previous tenants.

Reflective motivation Reuse
The design influences motivation by the degree of capability and opportunity, but aspects of the products offered also influence the motivation to take over the product. Having the products in a visible location reminds people that they can reuse, which might motivate them.

Automatic motivation Reuse
When the inhabitants walk past the reuse location they are triggered to take an item if they see something. If they also walk past this point when throwing items away, they can be triggered to offer it for reuse first before throwing it away in case no one takes it after some time.

Recycle Materials:

Physical capability Recycle Materials
The physical capability was positive in both cases. None of the interviewees mentioned that they were not physically capable of recycling materials.

Psychological capability Recycle Materials
The designs are such that the inhabitants are not always reminded to separate waste. The designs also fail to inform the inhabitants on the proper practice of separating waste. The psychological capability is therefore negative in both cases. In Case B the inhabitants are informed by roommates in grouped housing, but they are also not properly informed on the correct practice.

Physical opportunity Recycle Materials
The physical opportunity was mixed for both cases. The difference was mostly in the location of the waste collection facility. Having it on the way for all residents or near it, is a way of positively influencing their degree of opportunity. The capacity of the bins should be enough to handle the amount of waste produced by the inhabitants, which was not the case for paper and glass. Finally the costs and space required to make several bins in the studios is another major factor for interviewees to not separate waste. So providing bins in the studios would be an effective way of increasing the physical opportunity in these cases. In the grouped housing the bins were already there which positively influenced new inhabitants to also separate waste.

Social opportunity Recycle Materials
The organisation provides bins for the collection of separated waste at the waste collection facility of the buildings, which shows that the organisation cares about recycling materials. The visibility of waste collection was different in the cases. In one case the waste collection facility was visible and out in the open, but it often looked neglected and dirty. So making the waste collection visible can have a positive influence on the capability, but might have

a negative influence on the social opportunity if it is neglected or dirty.

Reflective motivation Recycle Materials
The design influences motivation by the degree of capability and opportunity, but personal values and knowledge of the inhabitants also have a major influence on the interviewees to separate waste or not. A high degree of motivation can overcome a low degree of capability and opportunity. But the designs of the buildings are not focused on increasing the motivation of the inhabitants. The design fails to inform the inhabitants on importance of recycling.

Automatic motivation Recycle Materials
For automatic motivation no aspects have been found.

Based on the findings and synthesis recommendations can be made for the future practice of designing for the specific behaviours.

SQ6: "Based on the lessons learned from the theoretical background and empirical research, which recommendations can be made for the future design of student housing complexes to stimulate circular behaviour?"

General recommendations

In the literature study it became clear that when designing for circular behaviour, first it must be decided on which behaviour the design focuses on. The literature overview provided several possible circular behaviours to choose from when conducting this research. It is crucial to understand which aspects are necessary to show the behaviour. As found in the case studies, the interviewees are responsible for creating their own personal waste separation system, which is regarded as a threshold to show the behaviour. According to Niedderer et al. (2014), one of the four ways to influence behaviour is to make the behaviour easier to do. This is possible by increasing the degree of capability and opportunity of the context and users, which will influence the motivation in a positive way, potentially leading to showing the desired behaviour. To do so, the context and user must be researched for the specific behaviours in their specific contexts. When more research has been done, the findings might be transferred to similar cases and should be readily available to use, but still it is advised to research and understand the specific context and user that is being designed for. When designing for circular behaviour in an existing situation it is recommended to perform a case specific study. When designing a new building, the design principles that are found from existing situations can be applied to the design.

The design principles found in the researched cases that influence the degree of capability and opportunity are presented below, along with the matching choice architecture techniques to design with.

-Distance = B2
-Availability =B3
-Duration = B1, B2, B3
-Accessibility = B2,B3
-Visibility = A2, B3
-Convenience = A1, B1, B2, B3
-Costs = B2, B4, C2
-Informing = A1, A2, A3, C1

The brief of the newly designed buildings that strive for circular behaviours should contain requirements that focus on positively influencing the COM-B aspects. This way designers are forced to take the influence of their design decisions on the behaviour of the residents into account. In the paragraphs below the recommendations for the specific behaviours of Reuse and Recycle Materials are stated based on the findings of this research.

There are also parts that are not related to the design but to the organisation of the building. For example, the housing association can provide rules and aids for showing the behaviours. As found in the empirical research, the capacity of the papers bins was not enough in one case. This should not be the job of the architect to solve, but rather the housing association by either emptying the bins more often or by providing more bins. Or when providing information on how to recycle waste, this could be done in many ways, but should not necessarily be left to the architect. The design of the kitchen or bins could be adjusted to meet this need.

Specific for Reuse

When designing for reuse this leads to the following recommendations: In Case B it was found that the visibility and location of the reuse spot were such that every resident should be aware of the availability of items when they are being offered. When an inhabitant enters or leaves the building they walk past this reuse spot, which is also next to an elevator, making it easy to move the items to a different level. There also is a trolley which makes moving the items on the same level easy. The fact that the items are offered for free also makes it more likely that items are taken over. The only thing that was not clear are the rules about the reuse, as the housing association prohibits placing items in the entrance hall, but inhabitants still offer things. By having more information provided this might stimulate more reuse behaviour in the building. In Case A was a similar postive situation except that there was no trolley, and not all inhabitants pass by the reuse location when entering and leaving the building. Therefore not the entire building is stimulated to reuse in the same way. By creating a possibility to offer items for reuse at entrances of the building can increase the chances of the residents showing reuse behaviours.

Specific for Recycle materials

When designing for recycle materials the following recommendations can be made: In both cases there were bins always available for waste collection on a building level. One of the cases did not have a organic waste collection bin which leads to no organic waste being collected. So the first recommendation is to facilitate collection of all different types of waste. In both cases the inhabitants have to create their own waste collection system at home. The small size of the studio is considered to be a limiting factor to start waste separation. There is a misunderstanding on the amount of space that is required to separate waste. If an efficient and small waste collection system is provided for every studio, it removes some of the barriers preventing people from starting to separate waste. The next recommendation is to make the waste collection visible, as this will remind people that the waste separation is possible. The behaviour of waste separation is one that requires explanation on how to do it properly. Therefore the inhabitants need to be informed on how to do it. There are also people who are not convinced of the impact of waste separation and they should be informed on the necessity as well. As mentioned in Case A, the distance to the waste collection point can influence people's decision on waste separation, by placing the waste collection on the way it makes it more convenient for people. Finally, the designs should inform the users on how to properly recycle materials, as the interviewees stated they got their information from unreliable sources. They get it from other people who are not properly informed either.

It must be noted that following all the recommendations will not ensure that people will actually show the desired behaviours. It only increases the chance that they will do it as important factors are positively influenced. However, behaviour can not be predicted with hundred percent certainty. After implementing the design interventions, the research should be performed again to see if new factors show up, and if the desired effect is also perceived by the users.

In this chapter the conclusions per sub question are presented all together. The chapter concludes with a main conclusion about the entire research.

Answer to SQ1: What is circular behaviour in the built environment?

Based on the literature review a couple conclusions can be drawn. There is not yet a standard for measuring circular behaviour. What circular behaviour contends is dependent on the type of stakeholder.

The goal of this research is to describe the relationship between a design and the circular behaviour. The scope of this research is the circular behaviour of students living in student housing complexes. Therefore, to answer this subquestion the focus lies on the stakeholder of inhabitant. The 10R model of Vermeulen et al. (2018) shows possible behaviours of consumers linked to Refuse, Reduce, Resell/Reuse, Repair, and to Recycle Materials. The inhabitant can be regarded as a consumer, so these behaviours relate to them.

When looking from the perspective of circular consumption behaviour, the R's can be traced back into desired behaviours for circular business models as stated by Selvefors et al. (2019) and confirms that these behaviours are also wanted by circular businesses. However, the circular business models also require behaviours that are not presented in the 10R model such as providing information about the product to the manufacturer.

Based on the literature study, the following definitions for circular behaviour are defined:

A short definition of circular behaviour is: Value retaining behaviour that leads to closing and or slowing circularity loops.

A longer definition that focuses on inhabitants is: Value retaining behaviour that leads to closing and or slowing loops such as Refuse, Reduce, Resell/Reuse, Repair, Recycle materials and other behaviours that help circular business models function.

Answer to SQ2: What factors influence behaviour?

The literature review provides multiple theories of behavioural models. The models are categorised into different goals and contexts. Even though none of the models will provide a 100% accurate prediction on what behaviour will actually take place, they provide valuable insight into factors that influence behaviour.

The Goal Framing Theory contends that goals change the way people perceive information, change the way they think and act upon different kinds of information. It also contends that there are three different kinds of goals: Hedonic, Gain, and Normative. From the goals, the normative goal provides the most stable behaviour outcomes. The different models are focused on separate goal types and have different factors leading to behaviour.

The theory of planned behaviour (TPB) shows three different aspects that lead to an intention or behaviour. The perceived behavioural control can be influenced by a design, the social subjective norm can be activated, but the attitude and intention will most likely not be directly influenced by architectural design. By making it easier for people to exercise certain behaviours, their feeling of perceived behavioural control can improve, leading to the desired behaviour. By providing eyes on the street, or a normative context, the social subjective norm can be activated.

The value belief norm theory (VBN) contends that a chain of a person's values, awareness, sense of responsibility, and personal norms can result in pro-environmental behaviour. An architectural design might only provide information when it's vision is pro-environmental and aspects of the design actually create awareness. Whether people feel responsible is up to people themselves.

Internal and external cues can trigger habitual behaviour. Habitual behaviours are automatic and not necessarily in line with a person's values or norms. Habits thrive in a stable context, and a new context allows for habit disruption and the formation of new habits. Habits require frequency, stability, success and automaticity. So only daily or weekly behaviours can be categorised as habits.

Contextual factors also influence behaviour. Contextual factors are the availability, quality, supply, price, physical infrastructure, intrapersonal factors, technical facilities and other product characteristics. It could be that individual factors are actually pro-environmental, but the context is not. Resulting in refraining from pro-environmental behaviour. Therefore, careful consideration of context in relation to individual factors is important.

The COM-B model addresses many aspects that are mentioned in the previously mentioned theories and simplifies them into three main and six separate subcategories. The theory contends that when the three main categories are positive, a behaviour is shown. This makes it possible to research if there are negative aspects that prevent a behaviour from being shown, and what aspects are positive that stimulate a behaviour. This simplification into six researchable subcategories allows for easy implementation in research.

Answer to SQ3: In what way does design influence behaviour?

As found in sub question 2, there are many factors and different theories for explaining behaviour. However, there is not one model that provides the final answer to the most important factors that determine behaviour. So it depends on the desired behaviour context and on the individual, which models would be of the best use. When designing for behaviour change, it is important to first pick a desired set of behaviour that has to be influenced. After deciding on the behaviour, use of a behavioural model is necessary to determine the most important factors to manipulate with a design. In the literature review research on Design for Behaviour Change from Niedderer et al. (2014), there are four main approaches to designing for behaviour change:

-To make it easier for a user to show the desired behaviour
-To make it more difficult for a user to show the undesired behaviour
-To stimulate users to show a particular behaviour
-To make users refrain from showing a particular behaviour

According to Niedderer et al. (2014), there are three categories of designing for behaviour change:

-Approaches that target the individual
-Approaches that target the context
-Approaches that target the middle-ground

The design for circular behaviour approach from Wastling et al. (2018) mixes the research of desired behaviours with a behaviour change model and business models. It also provides clear steps for developing a design for circular behaviour:

Step 1, Specify desired circular behaviour
Step 2, Research context and user with user-centred design research strategies using the COM-B model
Step 3, Develop design interventions with a design tool and business model aspects
Step 4, Prototyping, testing in real life

The same kind of steps are used in research on designing choice architecture intervention by Münscher et al. (2015). They suggest a framework with interventions for influencing the decision making process by giving three categories. Decision information, decision structure and decision assistance. The steps in their framework are the following:

Step 1, Define behavioural problem and target behaviour
Step 2, Analyse applicability of choice architecture framework
Step 3, Check for behavioural bottlenecks (defined as: does the cause lie in the psychology of human decision making)
Step 4, Build hypotheses on promising choice architecture interventions

The Shikake also mentions behavioural models, and stresses the importance of determining the desired behaviour. By providing physical triggers, psychological triggers are activated which result in behaviour. This design aspect is mostly focussed on product design and could be implemented in the design for circular behaviour.

Environmental psychology provides two intervention categories. Informational and structural interventions. The informational interventions focus on changing perceptions without changing the physical context and are effective when pro-environmental behaviour is convenient and not very costly in terms of money, time, effort and social disapproval. The structural interventions focus on changing the circumstances and are more costly, but

also more effective as only providing information is rarely enough for behaviour change.

Answer to SQ4: Which aspects need to be operationalised to conduct an empirical research on the influence of design on behaviour?

The literature study provided information on what aspects need to be present in a framework to perform an empirical study. The literature review provides many insights regarding circular behaviour, behaviour theories, and design for behaviour practice. When designing for a certain behaviour, first a specific behaviour has to be chosen to design for. The third subquestion provides the answer that a behavioural model should be used when designing for behaviour change. For the development of the framework in this study, the COM-B theory is used because it is an integrated model of many behaviour theories. It is also stated that a design technique should be used that focuses on behaviour change. For this research, choice architecture is chosen because it focuses on the decision-making process. All these factors are put into a flexible analytical framework that will be adjusted based on the chosen behaviour and the findings of the context and user research. The framework is presented in table 8 op page 27. The framework is used to inventorize the different aspects related to behavioural categories. The influence of the aspects are shown with colour coding and textual explanation. Green indicates a positive influence, yellow is mixed, red is negative. This flexible analyitical framework is then translated to specific behaviours for the emprical research.

Answer to SQ5: What influence do designs have on the circular behaviours of Reuse/Resell and Recycle Materials of inhabitants in current practice in student housing complexes?

It can be concluded that the design of the buildings influenced the interviewees in multiple ways. The analytical framework was successfully employed in the cases for the specific behaviours and provided many insights into different design aspects that influenced different factors that determine behaviour. Some factors were not related to the building, but rather to products, culture, personal preferences or financial. It became clear that for the psychological capability, the design fails to inform the interviewees on the proper practice of the behaviour. The physical opportunity was very positive for Reuse, but not so for Recycle Materials. Nevertheless, most of the interviewees still showed both behaviours to a certain extent. The factors related to the design of the building were the Distance, Availability, Costs, Convenience, Visibility, Accessibility, Duration and Information. These are mentioned as the degree of capability and opportunity which influence motivation according to the COM-B model. It was also found that some interviewees were highly motivated, which overcame a perceived low degree of opportunity. This high motivation caused them to personally increase the degree of physical opportunity for themself. Likewise, a high degree of capability and opportunity could motivate a unmotivated person to show a behaviour.

Answer to SQ6: Based on the lessons learned from the theoretical background and empirical research, which recommendations can be made for the future design of student housing complexes to stimulate circular behaviour?

A few recommendations have been made based on the findings of the research. The main recommendation is to increase the degree of opportunity and capability to prevent people from refraining to show behaviour from aspects that can be controlled. The recommended design principles that should receive extra attentention are: Distance, Availability, Duration, Accessibility, Visibility, Convenience, Costs, and Informing. Suitable choice architecture techniques that are focused on these design aspects are also recommended. Based on the designs of the studied cases specific recommendations have been made for the behaviours of Reuse and Recycle Materials. There are limitations to the recommendations that they can't guarantee that the behaviours will be shown, as not every aspect of behaviour can be influenced by design only. Different stakeholders impact different parts of the design, so not all responsibility lies with the architect.

Main Conclusion: What is the relation between design and circular behaviour?

A design has influence on behaviour. When looking at behaviour through the lens of the COM-B model, there are different categories which are all affected by design. A design can make behaviour impossible by having a negative influence on one of the

three or more categories. A design can also make a behaviour possible, by changing the categories that are negative into positive. In between the two extremes of possible and impossible there is also the degree of the categories that influence behaviours. Someone could be able to show behaviour, but if it takes too much effort the person can refrain from showing the behaviour. If there is a high degree of capability and opportunity, it can motivate a person to show the behaviour, and likewise a low degree can demotivate.

For a smooth transition to a circular economy, circular behaviours should be defined more and their impacts measured. For each of the behaviours the context should be researched to what extent they influence behaviour. The flexible analytical framework in table 8 that was created in this research can be used to perform that research. If the context has a negative or low degree of capability and opportunity it should be changed to stimulate more circular behaviours. However, it must be noted that behaviour is a complex phenomenon with a multitude of factors that influence it, both conscious and unconscious. It is difficult to map all the different factors for every person. Not all factors are related to a design, there are also beliefs and values that have a big influence in behaviour.

In this chapter the discussion, limitiations and future research are presented. In the discussion the data and method will be evaulated and limitations of the data and research methods are mentioned. After that recommendations for future research are suggested.

Discussion and limitations

In this thesis, an attempt has been made to find the relation between design and behaviour. To do so, a decision has been made to make use of a specific behavioural model, the COM-B model. Many theories have been presented in the literature study but these were specific to one type of goal as mentioned by the goal framing theory. The COM-B model provided a clear overview that categorised most of the factors of the different theories in one model, making it easy to use in an empirical research. The other theories would only focus on one type of goal, making it necessary to fill in multiple frameworks or tables per behaviour to get a complete picture. However, behaviour is a very complex subject which has many factors that influence it. There are factors unrelated to the design that determine the way a person behaves with or around the designed item. The COM-B behavioural model helped to provide a scope to research specific aspects that influence behaviour. The theory helps to determine whether people should be capable and have the opportunity to show the behaviour. If these aspects are positive, the person only needs to be motivated to show the behaviour. Aspects that are not included in this model are factors such as age, sex, and education. Factors that were not taken into account could have influence on the behaviour of the interviewees as well. The COM-B model is an accepted model by multiple sources and is used successfully in designing interventions in other fields such as healthcare.

When inventorizing the different aspects that influence behaviour, using the analytical framework, it was difficult to place them in only one category for some aspects. For example distance has influence on a person's physical capability, if the person is physically not fit to walk a certain distance. The distance also influences the physical opportunity because the further away something is, the longer it will take to get there. Someone also can state that the distance is the reason they do not

do something, for which it could be regarded as a reflective motivation. In this case the person might be physically capable to walk the distance, have the time to walk the distance, but still is not motivated because the effort is considered too much. A different person might not perceive the same distance as too far and thus show the behaviour. This shows the personal nature of the findings, which can be generalised, but not to be expected to work for everyone as there are more factors that determine whether a person shows behaviour. Nevertheless, improving the degree of capability and opportunity can lead to increased motivation and showing the desired behaviours.

The method used allows to draw conclusions for the specific cases based on the empirical findings. In other cases different factors might influence the inhabitants, making the found factors irrelevant in that case. In the researched cases, the interviewees could have not provided true data. They might have refrained from saying things they are ashamed of or were not comfortable in sharing. It is also possible that they were not aware of factors that influence them. Therefore the findings are only true if the data that was collected is true. In order to make the interviewees comfortable to speak freely, part of the interview protocol was to stress that there are no right or wrong statements, and that the goal of the interview is to gain insight, not judge. To increase the comfort of the interviewee it was chosen to use an unobtrusive recording device. This makes it resemble a normal conversation instead of a recorded interview. It must also be noted that when interviewing people, only rational conscious behaviour aspects can be discovered, but a large part of behaviour is automatic, habitual. Habits are difficult to research with interviews.

The amount of interviewees is low due to low response of interviewees. A minimum of six per case has been achieved which can provide a sufficient amount of data to find differences and similarities. If more interviews were taken it would provide a few more data points which might lead to more factors that potentially influence behaviour. For Case B, all interviewees recycled more than just paper or glass. So data points on people that do not separate waste are missing for this case. The result can also be skewed because a person that will help in a research

by doing an interview for free might already have altruistic values which are also a precursor for showing pro-environmental behaviour. Therefore, the findings can be biassed towards a more positive outcome than in reality.

Finally, behaviour is a very complex topic to study. It can only be attempted to make a model that successfully predicts behaviour every time. Simplifying behaviour is necessary in order to be able to study different aspects, but the weighing of the aspects is different for every person. Also, for every behaviour there are sub-behaviours that precede the final behaviour. For example for separating paper waste, there are multiple actions. First a person has to set up a paper collection point at home, then he has to learn what waste is regarded as paper waste, then he has to start collecting paper waste at home, and then he has to offer it at the waste collection point. There are different factors with differing influence on the sub-behaviours.

Future research
As explained in the introduction, this research is an initial exploratory attempt to research the relation between design and circular behaviour. A lot of effort went into the understanding of behaviour and its connection to design and how to research this empirically. Therefore only two cases have been studied and few interviews have been done. The analytical framework can be expanded much more. By repeating the empirical study over more cases, more design aspects and examples can be found. Also a way to measure the importance of the factors should be researched. As some aspects can have a greater impact than others. This could be done with quantitave research methods.

This thesis focused on student housing, but the method can be applied to other functions as well, such as offices, parks, museums or other public places. Not only should the cases be researched as in this thesis, but the findings should also be tested and prototyped in existing and new cases. To do so the behaviours must first be measured in the existing situation and then compared with the results of the new behaviours in the new context.

Finally, the feasibility of the interventions has not been studied as it was not in the scope of this research. The costs and benefits of interventions that can be designed based on the findings of the research can still be researched.

In this chapter the choice of method and argumentation which preceded the research will be presented. It reflects on the chosen methods, the results and how the feedback that was incorporated by the mentors, and what has been learned.

Based on a gut feeling, the researcher's personal experience, lessons taught at the university of TU Delft, and findings from the literature study, the idea came to research the topic of influence of design on circular behaviour. The researcher might be biased because of the personal experience and living in one of the studied cases, but this also leads to a thorough understanding of the existing context and knowing where to look for asnwers.

A strong focus on building materials and business cases was found in the studied literature. Pilot projects have been found that relate to a small circular community or ways to reduce the environmental impact of construction. But few sources were found that adress the behavioural aspect of a circular economy. If more time was spent on the literature research, more sources might have been found that would provide insight into this topic. However, most literature found related to circular business models and not on circular behaviour in housing. The research of Vermeulen et al. (2018) provided a 10 R ladder which reviewed literature on circularity which provided a lot of value and a scope for this research. It was lacking some parts of the desired behaviours for circular business models such as informing on the state of the item to the business.

In the part of the literature review that focused on behaviour a few out of many theories have been examined in more detail. There might be other more suitable behavioural theories that could apply to this research. Due to time limitations and the practicality of the COM-B model, it was chosen to focus on the development of the framework using the COM-B model. Using a different model could have provided other results.

In the part of the literature review that focused on designing for behaviour change, again a decision has been made to use one of the presented models. Using a different model would lead to different results. But the decision to focus on choice architecture as design technique is valid as it focuses on changing the decision making environment.

For the case studies, it was chosen to focus on the context and the user as recommended by Wastling et al. (2018). As this is an initial exploratory research that aims to find the relationship between design and behaviour, leaving out the user who shows the behaviour would cause to miss out on important data. The chosen method to study the users was through semi-structured interviews, asking about questions related to the behaviour and the COM-B model, parts of the design were also part of the questions and how they influenced the interviewees. As stated in the discussions, the conclusions drawn based on the findings are valid, but the statements made might not be true as the interviewee might feel ashamed or not comfortable in sharing private information. The interview protocol did focus more on the behavioural aspect then on the design. In the next iteration of the research, more focus can be put on the design aspect.

The case selection was done based on a narrow scope and convenience. By focussing on one small sample group an initial exploration of the relationship between design and circular behaviour can be done. By increasing the scope, the findings would be more scattered, and by having a narrow scope, more confidence in the findings can be made.

This research has been influenced by the mentors in many ways. The original goal of the research was to not only find the relationship between design and circular behaviour, but to also find the best practice, make recommendations on the best circular design, and test the recommendations with architects, and provide a ready to use framework to design for circular behaviour in housing. It was recommended by the mentors to not do that much work, as the time limit of the thesis does not allow all these steps to be made. At the first P2 examination, which failed, the scope of the research was too broad and vague which deemed the research impossible to carry out. At the retake the research was made more specifc to two specifc behaviours instead of seven vague behaviours. The mentors helped in making the research presentable and more clear. Giving critical feedback when necessary. However, the creation of the analytical framework took a long time, leaving little amount of time to do emprical

research. After an intial enthausiastic response of two cases, the related organisation refrained from allowing the continuation of the research on their cases, missing out on valuable information on designing for circular behaviour. The original plan was to research five cases, instead of two, which would provide insight on more design aspects and how they influence circular behaviours.

The findings of this research are transferable to other researches as the framework and method used can be used to research multiple other cases in different contexts and with different behaviours. However, when transferring the findings of the specific cases, it should be noted that they might not work for every case, as they are specific to the situation. The findings can be taken into account when renovating or transforming an existing building, or when designing a new building.

In the master track of MBE, multiple fields are combined into a general management track. One of the fields is Real Estate Management (REM), which concerns itself with facilitating the users of the built environment, while optimally contributing to societal and organizational goals, climate challenges and economic feasibility. The topic of this thesis is about smoothing the transition towards a circular economy by changing behaviour in the built environment through design resulting in lower environmental impact of the use of buildings. The goal of the Netherlands is to reach a fully circular economy by 2050, making it a relevant topic for REM. In the master programme, circularity has been addressed in different courses. In one of the courses, Urban Redevelopment Game, there was a new role called "Circular Economy Manager". In this course, a first deep exploration into circularity is done and its complexity and many problems that need to be solved are presented. This research aims to solve one of the problems, which is changing the built environment to enable and stimulate circular behaviours resulting in circular activities.

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APPENDIX - A

10 Steps to replicate the study

This document serves as a manual to replicate the study. For more extensive explanations the reader is referred to the thesis. By following the steps laid out below, the relationship between the specific design and behaviour of the researched context can be found. By changing the context using the choice architecture techniques to enable categories of the COM-B theory, it is likely that more people will show the desired behaviour. However, behaviour is complex and the results can not be guaranteed.

Step 1, Choose desired circular behaviour and make it specific

The researches of Vermeulen et al. (2018) and Wastling et al. (2018) provide lists of possible circular behaviours to choose from. These are presented in the figure below. Be aware that these behaviours are broad terms and can be made more specific. For example, when researching Recycle Materials, there can be a different influence on different kinds of materials. Someone could recycle glass but not paper. So it is recommended to make clear which waste streams are being researched and to filter the findings accordingly.

Type of behaviour	Example bevaviour
R0 Refuse	-choice to buy less, or use less; -reject packaging waste and shopping bags
R1 Reduce	-using purchased products less frequently; - use them with more care and longer.
R2 Resell/re-use	-buying second hand, or finding a buyer for a product that was not or hardly in use, possibly after some cleaning or minor adaptations restoration; -use online consumer-to-consumer auctions for used products
R3 Repair	-by the consumer in their vicinity, or at their location, or through a repair company; -or at a 'repair café'
R7 Recycle Materials	-give back as separate waste streams

Table 3: Excerpt from table 2 (Vermeulen et al., 2018).

Figure 2: Model of Circular Behaviour: an outline of desired behaviours for circular business models (Wastling et al., 2018, p. 9)

Step 2, Translate the general aspects of the COM-B, table 8, to the desired behaviour

After deciding on a behaviour, understanding of the COM-B theory is necessary. In the literature research of sub question 2 of this report is an explanation on the COM-theory and in sub question 4 is a detailed explanation of the different categories and subcategories. In Appendix B the definitions are displayed on a cheat sheet to use during the empirical research. The report also provides examples of translations from table 8 to Reuse and Recycle Materials to use as guidelines. The table that results from this step will be used as a starting point and will be further developed in later steps.

COM-B aspect	Design aspect	Choice technique	Influence
Capability physical	Distance	B1,B2	
	Weight	B2,B3	
	Accessibility	B2,B3	
	Height	B1,B2	
	Thresholds	B2,B3	
Capability psychological	Difficulty	A1,B2,B3,C1	
	Access to information	A2	
	Reminders	C1	
	Understanding	A1,A2	
Opportunity physical	Availability of inanimate objects	B1,B3	
	Duration	B2,B3	
	Costs financial	B2,B4	
	Costs social	B2,B4	
	Distance	B1,B2	
Opportunity social	Rules from organisation	A3,B4,C2	
	Norms	A3	
	Culture	A3	
	Participation	A2,C2	
Motivation reflective	Informing	A1,A2,A3	
	Important factors	depends	
	Reminders	C1	
	Rewards	B4	
	Punishment	B4	
Motivation automatic	Cue's	B1	
	Triggers	B1	
	Direct feedback	B4	
	Stable environment	B1	

Table 8: General table with specific combination of COM-B aspects and Choice Architecture techniques (Own creation)

COM-B subcategory	Choice architecture technique
Capability physical	B1, B2, B3
Capability psychological	A1, A2, B1, B2, C1
Opportunity physical	B1, B2, B3, B4
Opportunity social	A2, A3, B4, C1, C2
Motivation reflective	A1, A2, A3, B2, B3, B4, C1, C2
Motivation automatic	A2, B4, C1

Table 7: Combining choice architecture with COM-B based on definitions provided by Vermeulen et al., (2018) and Wastling et al., (2018)

Step 3, Analyse applicability of choice architecture framework

In the literature research of sub question 4 of this report a thorough definition of all choice architecture techniques is given. In Appendix C this same information is displayed on a cheat sheet to use during the empirical research. Also predetermined combinations are given that can be used to speed up the process of deciding on a choice architecture technique. This table is presented in table 7. By looking into what choice architecture techniques affect which categories of the COM-B theory, a general understanding of how the design could influence different parts of behaviour is found.

Step 4, Analyse the context with document analysis

Step 2 is used as a basis to look for what parts of behaviour are influenced by the design. By looking at floor plans and other relevant documents about the organisation of the building, new aspects could arise that were not found during the initial set up of the framework. These should be added and if possible their influence should be mapped with colour coding and textual descriptions. A green colour coding indicates a positive or high degree of influence. Yellow indicates a mixed or low degree, it might be positive for some but negative for others. Red indicates a negative influence. The textual description provides information on what aspect has that influence. In table 6 an example of this operationalization is presented.

Capability physical	Behaviour Y
Distance	5m
Weight	100kg
Accessibility	Not wheelchair accesible
Height	1m
Thresholds	Staircase

Table 6: Operationalisation example of table 5 (own creation)

Step 5, Create interview questions based on COM-B framework

To prepare for the next step of the user centred research, interview questions that look into how or why people show behaviour have to be formulated. In Appendix D an example is given of what the interview questions looked like for this research. There are some general very open questions that allow for the interviewee to provide insight in all different aspects of the behaviour. There are also a couple questions specifically aimed at aspects from sub categories of the COM-B theory. The goal of the interviews is to find new design aspects, to find their influence and to validate findings of the document research step. Depending on the answers to the questions, some questions do not have to be asked as they are already answered. However, it is important to take into account whether all aspects have been addressed.

Step 6, Perform semi-structured interviews with users

The general advice for the amount of interviewees is to keep interviewing new people until no more new findings are made with a minimum of six people that show and six people that do not show the behaviour. If there is a time limit it is advised to interview at least six people that show and six people that do not show the behaviour. When performing the interviews, the interviewer is free to ask new questions to gain a deeper understanding of different aspects. If more behaviours are researched at the same time, the interviewer should only proceed to the next behaviour when he is certain that aspects of all sub categories of the COM-B model have been answered. The interviews must be recorded and transcribed to analyse the transcripts in step 7.

Step 7, Analyse transcripts with COM-B coding and find new aspects

After interviewing, the transcripts must be analysed with predefined open coding of the subcategories of the COM-B theory. They allow for the emerging of new themes that are then easily categorised according to the COM-B theory. To do so, use the definitions of the subcategories as presented in appendix B to determine which newly arised themes are most suitable to which subcategory. It is possible that multiple categories are affected by a single theme, in that case mark them down on both categories of the COM-B theory, as they might have a different influence on the different categories. Make a list of the newly found aspects and look for overarching themes that can be added to the framework. It is suggested to use software such as Atlas.Ti for analysing the transcripts. In the figure below, an example co-occurence table is presented which shows how many statements have been made that relate to a specific behaviour and to a subcategory of the COM-B theory. There is also a difference in positive and negative statements.

	recycle glass Gr=31	recycle paper Gr=34	recycle pmd Gr=37	recycle rest Gr=20	reuse in-house Gr=47
○ Capability physical Gr=24	10	10	6	6	8
● Capability physical negative Gr=5	1	-	-	-	1
○ Capability psychological Gr=27	10	10	7	6	13
● Capability psychological negative Gr=10	3	4	4	1	5
○ Motivation automatic Gr=4	2	2	2	2	2
● Motivation automatic negative Gr=4	-	-	-	-	1
○ Motivation reflective Gr=25	4	2	5	3	12
● Motivation reflective negative Gr=18	2	6	8	2	4
○ Opportunity physical Gr=31	8	9	8	6	17
● Opportunity physical negative Gr=14	6	8	10	3	2
○ Opportunity social Gr=23	6	5	6	4	15
● Opportunity social negative Gr=10	4	3	4	1	6

Figure 28: Co-occurence table from Atlas.TI

Step 8, Map influence of aspects in general

By stacking all different results of the interviews it is possible to map an overarching general influence of the design on the behaviour of the residents. This way the clear overview provides insight if one of the main categories is very negative. This can indicate that the behaviour is negatively influenced by the design. However, to gain more in-depth insight step 9 is necessary. In table 20 the findings of Recycle Materials is shown for one of the cases of this thesis. It can be seen that the physical opportunity is moslty negative or mixed. The other categories are more positive.
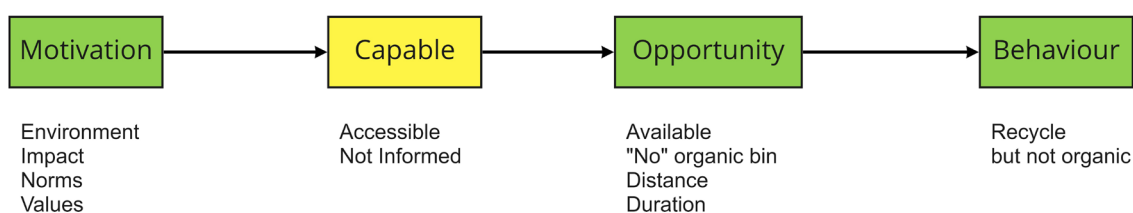
COM-B aspect	Design aspect for Recycle Materials	Choice technique	Case B
Capability physical	Accesibility	B2	Present
	Elevator	B2	Present
Capability psychological	Inform about what goes where	A1,A2,B2	Roommates, other people
	Reminders to do it	C1	There are bins to separate at the collection point
	Visible	C1,A2	In a seperate room that is hidden
Opportunity physical	Distance to bins	B2	45m-125m
	Different bins at home	B1,B2,B3	In group housing yes, studio missing, small studio lacks space
	Different bins at the collection point	B1,B2,B3	Present, but hidden
	Take away the costs such as buy your own bins	B2	Missing
	Capacity bins for building	B2	Glass
	Size of studio	B2	Too small
Opportunity social	People participate collectively	A3,B4,C2	Present
	Visible culture	A2, C2	Collection point hidden
Motivation reflective	Provide information on impact of recycling materials	A2, B4	Missing
	Reward or punish behaviour	B4	Missing
	Convenience	B2	Bins always available
	Stinking bins	B4	Not mentioned
	Not wanting to put effort	B2	Not separating all waste
	No one is forcing	A3,C2	Unclear
	Roommates do it	A3	For group housing
	Environmental reasons	A2	For most interviewees
Motivation automatic	New location allows for new habits to form	B1	Present

Table 20: Findings of interviews in the analytical framework for Recycle Materials in Case B

Step 9, Map different "customer journeys" of users

By looking at the different experiences between users, different patterns can be found. The most important part is to find whether the interviewee was motivated before interacting with the design, if the design motivated them to show the behaviour, or if the design demotivated them to show the behaviour. By looking into the different experiences insight can be gained on different principles and how a single category could be negative for one person. One person might regard the distance of 50m as close, while another might regard it far away. In figure 18 an example of findings of one of the cases is presented. One of the interviewees was already very motivated to Recycle Materials and the design did not stop him from showing the behaviour. Two other interviewees mentioned how the design makes it very difficult for them to Recycle Materials and that is one of the main reasons that they do not do it.

Interviewee 3 Recycle

Motivation	→	Capable	→	Opportunity	→	Behaviour

Environment	Accessible	Available	Recycle
Impact	Not Informed	"No" organic bin	but not organic
Norms		Distance	
Values		Duration	

Interviewee 5 & 6 Recycle

Accessible
Not informed
Visible
Distance is too far

Degree of Capable		
	Motivation	→ Behaviour
Degree of Opportunity		

Too much effort   No Recycle

Available at collection
Not available at home
Distance is too far
It is not convenient
It is not on the way
Size of studio

Legend
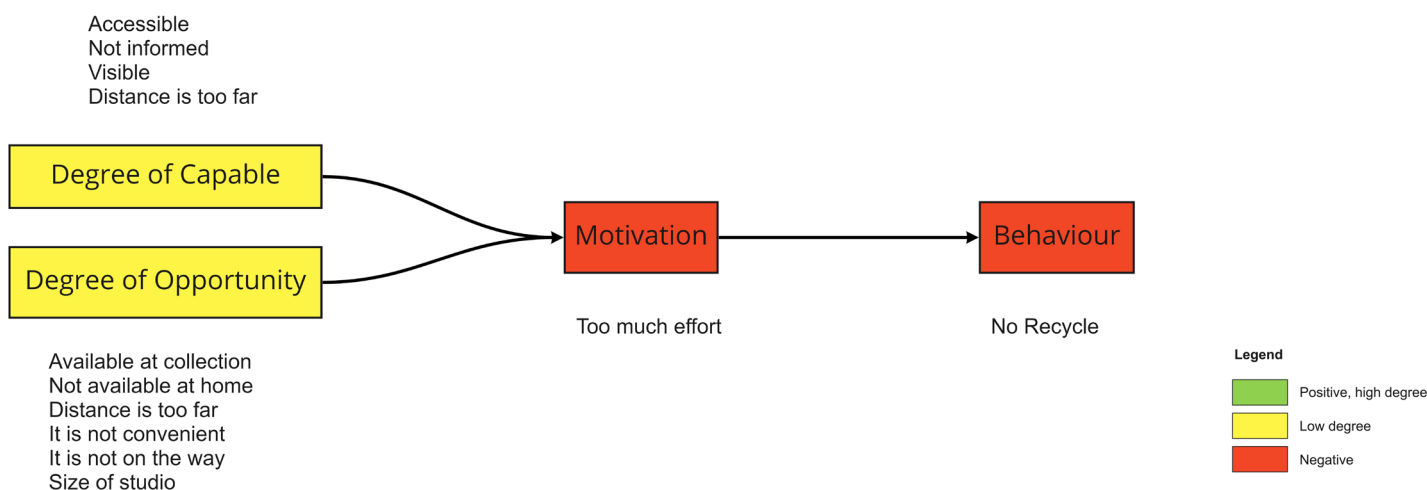Positive, high degree
Low degree
Negative

Figure 18: The design aspects that influence behaviour mapped in order according to the COM-B model for Recyle Materials in Case A

Step 10, Choose suitable choice architecture techniques to design for positive influence

After finding the new themes, suitable choice architecture techniques should be chosen to design with. The table from step 3 shows techniques per part of behaviour to speed up the process. Appendix C can be used to see the definitions of the different techniques. After implementing the interventions the research can be iterated to determine the influence of the new design on the behaviour.

Final words

By following these steps, more insight in the relation between the design and behaviour in the studied context can be gained. However, making changes based on the findings will not ensure that the desired behaviour will be shown as there are more factors that determine behaviour.

APPENDIX - B

Definitions of COM-B subcategories

To determine which aspects might affect the different sub categories, the definitions of the subcategories as given by West and Michie (2020) are used.

Physical capability
The physical capability relates to aspects that influence the physical aspect of behaviour. Whether you are strong enough to lift something up, whether you are able to walk up and down the stairs, and if you can make certain movements. These translate to the generic aspects of distance, weight, accessibility, height and thresholds.

Psychological capability
The psychological capability relates to mental aspects such as understanding and memory. The difficulty of the behaviour, having access to information, being reminded or taking lessons might influence the psychological capability.

Physical opportunity
The physical opportunity is not only the environment or objects, but also about time, financial and material resources. This can be influenced by adding objects to an environment or removing them, by changing the duration of the behaviour can also make it more or less possible as time is a limiting factor. Costs also determine whether someone can pay for the behaviour, and by changing the distance, it also has influence on the duration, but also could result in an increase of financial costs due to travel expenses.

Social opportunity
The social opportunity relates to how other people and the organisation of a location help or disapprove of the behaviour. This might be influenced by culture, norms or rules. Also having (more) people present at a location might influence the social opportunity.

Reflective motivation
The reflective motivation is about planning and evaluation of the behaviour. The evaluation first happens by what is already known to the person. By informing people about a behaviour, they can weigh the new pros and cons and might decide to adopt a new behaviour or not. Certain aspects from other aspects will also act as information in the decision making process. For example, the conscious decision not to separate waste because the distance to the bin is regarded as too big. This causes the motivation to be negative, even though the person is physically capable of walking the distance, and has the physical opportunity of time to do it, but a closer bin might also lead to positive motivation to separate waste. Finally, the rewards that might come with a behaviour can lead to a positive motivation, but when the reward is removed, the behaviour can disappear as well.

Automatic motivation
Finally, automatic motivation is about habitual or instinctive behaviours that are done without conscious thought. Habits react to mental or environmental cue's and triggers. These habits are usually formed by direct-feedback mechanisms. An environment can also trigger automatic behaviours, so a change of environment can lead to breaking habits and forming new ones.

APPENDIX - C

Choice architecture techniques explained

In order to make the connection between behaviour design aspects and design techniques, the different techniques and their means are explained in this section based on the research from Münscher, Vetter, & Scheuerle (2015).

There are three main categories of techniques. The first category is (A) decision information where the techniques focus on different ways of presentation of relevant information without changing the options of behaviour. The second category is (B) decision structure, which is about changing the arrangement of options, effort needed and consequences. The final category is (C) decision assistance which can be done with reminders or commitments.

Category	Technique
A. Decision information	A 1 Translate information *Includes: reframe, simplify* A 2 Make information visible *Includes: make own behavior visible* *(feedback), make external information visible* A 3 Provide social reference point *Includes: refer to descriptive norm, refer to* *opinion leader*
B. Decision structure	B 1 Change choice defaults *Includes: set no-action default, use prompted* *choice* B 2 Change option-related effort *Includes: increase/decrease physical/* *financial effort* B 3 Change range or composition of options *Includes: change categories, change grouping* *of options* B 4 Change option consequences *Includes: connect decision to benefit/cost,* *change social consequences of the decision*
C. Decision assistance	C 1 Provide reminders C 2 Facilitate commitment *Includes: support self-commitment/public* *commitment*

Table 4: Choice architecture categories and techniques (Münscher, Vetter, & Scheuerle, 2015, p. 514)

COM-B subcategory	Choice architecture technique
Capability physical	B1, B2, B3
Capability psychological	A1, A2, B1, B2, C1
Opportunity physical	B1, B2, B3, B4
Opportunity social	A2, A3, B4, C1, C2
Motivation reflective	A1, A2, A3, B2, B3, B4, C1, C2
Motivation automatic	A2, B4, C1

Table 7: Combining choice architecture with COM-B based on definitions provided by Vermeulen et al., (2018) and Münscher et al., (2018)

A1: Translate information
Information can be translated through the reframe technique. For this technique it is not allowed to provide new information. But for example to reframe information from live-saving to death-preventing does count. Another technique to translate information is to simplify already available information to for example rules of thumb or plain language.

A2: Make information visible
By making (new) information visible people will become aware of invisible consequences. Giving feedback about one's own behaviour can be done for example by a smart electricity metre showing energy consumption. But also external information can be made visible. For example, a label that displays the level of hygiene of a restaurant can help people to avoid a restaurant with a bad label.

A3: Provide social reference point

People do not make decisions or behave in a vacuum but in a social and cultural context. The behaviour of other people influences people's own behaviour. By referring to the descriptive norm, which is what people are doing that can be observed, people can be stimulated to show the same behaviour. It is possible to refer to the group or to the opinion of a respected leader.

B1: Change choice defaults

Defaults are pre-selected options that allow decision-makers to deliberately choose a different option. People accept the default in many instances. The no-action default refers to what happens when a user doesn't make a choice. The opposite is a prompted choice which forces people to decide, which is helpful for a heterogenous group where a default option might not work.

B2: Change option related effort

The amount of effort required has a significant impact on which of the numerous possibilities an individual will select. For this choice architecture technique the change in effort can only be marginal. Else it would count as manipulating standard economic transaction costs. The option related effort can be changed by increase or decrease of physical effort, financial effort or duration of the behaviour.

B3: Change range or composition of options

It is also possible to change the amount of options that are given. People also make decisions based on what the alternatives have to offer.

B4: Change option consequences

By connecting benefits or costs to a decision it is also possible to influence behaviour. This can have monetary or social consequences.

C1: Provide reminders

Sometimes people are aware of all necessary information but need to be reminded of them. These reminders can help to stimulate that behaviour, but there can also be reminders to oppress unwanted behaviours. The reminders are not allowed to provide new information for this technique.

C2: Facilitate commitment

Individuals who make a private or public commitment to certain actions are more likely to follow through because it helps them overcome self-control issues. Not adhering to the commitments can lead to losing face so it stimulates them to stick to the commitment.

Based on the definitions of the separate COM-B categories and choice architecture techniques, combinations are suggested in table 7. This table helps to speed up the process of selecting suitable choice architecture techniques to found aspects that need to change to enable behaviour.

Interview protocol

Aim of the research
To gain insight into the reasoning and motivations for showing circular behaviour in the context of student housing complexes and what role the design of the building plays in this. In order to gain the insight, inhabitants of student complexes will be interviewed to learn what factors influence them in the decision-making process to show circular behaviour or what factors make them refrain from showing it. The findings of the interview will be used to fill in and add new aspects to the analytical framework.

Method
The interviews are in-depth and semi-structured. This means that the interview questions should not be used as a rigidly defined conversation structure, but rather as a guideline. The content of the interview opens the possibility of new, unexpected insights. But also aims to answer predetermined factors from the COM-B theory. For every behaviour the goal is to find the influence on all subcategories of the COM-B theory. Therefor for every behaviour there will be probing themes related to the COM-B theory to further deepen the interview when necessary. Only when insight on all subcategories of the COM-B theory have been found the next behaviour will become subject of the interview. At the end of the interview the interviewees have the freedom to add their own statements if they feel like certain aspects have not yet been addressed. The interviewees will also be asked if there was a difference in showing the circular behaviours in other places they lived and if so why.

Procedure
This interview procedure gives the interviewer the ability to conduct each interview in a systematic and consistent manner. The scripted sections before the interview question are to be read to the interviewee to inform then in the interviewee before the recording starts. The protocol is for the interviewers and serves as an internal document and will not be shared with the interviewees. The specific behaviours that are researched will not be shared with the participants to prevent bias of only having respondents that show the behaviours. They only know that the research is on the influence of the building on their behaviour. The probing topics for all behaviours are:

Capability:
-Are you physically capable of showing the behaviour?
-Are you psychologically capable of showing the behaviour?

Opportunity:
-Do you have the physical opportunity to show the behaviour?
-Do you have a social opportunity that allows you to show the behaviour?

Motivation:
-Is it a conscious decision?
-Is it a habit?

Start interview:

Short introduction
Hello and thank you for participating in the interview, first let me tell you a little bit about myself who I am and what I do. My name is Teun and I follow the mastertrack of Management in the Built Environment

at TU Delft. For my graduation project I am investigating the influence of the design of the building on a number of types of behaviour. To do this, I would like to know more about your train of thought and actions associated with certain behaviours. There are no right or wrong answers, so don't worry about that. Your answers will remain anonymous, but I would like to record the conversation so that I can analyze it more easily. I will ask you at the beginning of the recording whether you are okay with me recording the interview.

The behaviors I research are reuse and separating waste. The first part of the questions will be about reuse in the building. Reuse is defined as taking over or handing over things for money or for free. And waste separation is about offering separated waste such as glass, paper, PMD, organic waste and the rest. Do you have any questions before we start the interview? If not, the recording of the interview will now start.

Start recording:

-Are you OK with me recording this interview for research purposes?
-Thank you, then the interview starts now! As explained, the first set of questions will be about reuse in the building.

Reuse self in-house   COM-B sub category:

1.	Do you ever reuse things from people inside the building?	all
2.	Why/why not?	all
3.	How do you find out that the stuff is available?	Mref
4.	Is there also a physical location where people place things?	Ophy
5.	Is there a digital location where people offer stuff?	Ophy & Osoc
6.	Are you ever reminded that you could reuse in the building?	Mref
7.	Are there clear rules regarding reuse in the building?	Osoc & Cpsy
8.	Are your neighbours active in reuse?	Osoc
9.	Is it visible? -does it happen in a dark corner or central-	Mref
10.	Do you take over things from people who move or from the previous occupant?	all
11.	What is the building management like with regard to reuse? Do they encourage it or make it difficult?	Osoc

Allow reuse others in-house

12.	Do you sometimes offer things in the building yourself?	all
13.	Why/why not?	all
14.	How do you let others know that you offer them?	Cpsy, Ophy & Osoc
15.	When you move, do you offer things to the next resident or neighbours?	all

Reuse general:

16.	Do you consciously think that no one can reuse your stuff?	Mref
17.	Do you need a reward for reuse?	Ophy & Mref
18.	Are you aware of the environmental impact of throwing things away?	Mref

Now for the second set of sub-questions is about waste separation. Separating waste is defined as offering different material flows separately such as glass, paper and plastic.

Separating waste

19.	Do you separate waste, yes or no? And why? .	all

if yes:	COM-B sub category:
20. How are the waste facilities in the building?	all
21. Does the distance to the bin influence your choice to separate waste?	Ophy & Mref
22. What types of waste do you separate exactly?	all
23. How do you decide which types you separate? What is the consideration?	all
24. How did you learn what goes where?	Cpsy & Osoc
25. Can you separate waste in the building?	Ophy
26. Do your neighbours separate waste?	Osoc
27. Are you aware of the impact?	Mref
28. Do you know what happens to residual waste?	Mref

if no:	
29. Does the distance to the bin influence your choice to separate waste?	Ophy & Mref
30. What types of waste do you separate exactly?	all
31. How do you decide which types you do separate?	all
32. Do you know how to separate waste?	Cpsy
33. Can you separate waste in the building?	Ophy
34. Do your neighbours separate waste?	Osoc
35. Do you consciously choose not to divorce?	Mref
36. Are you aware of the impact? 170kg per person on average per year	Mref
37. Do you know what happens to residual waste?	Mref

Building specific

38. How do you experience the building with regard to reuse?	all
39. How do you experience the building with regard to waste separation?	all
40. How have you experienced this in other homes? Did you do it more or less there? And why?	all

Thank you very much for participating in my research. I will stop the recording now!

Ending of recording