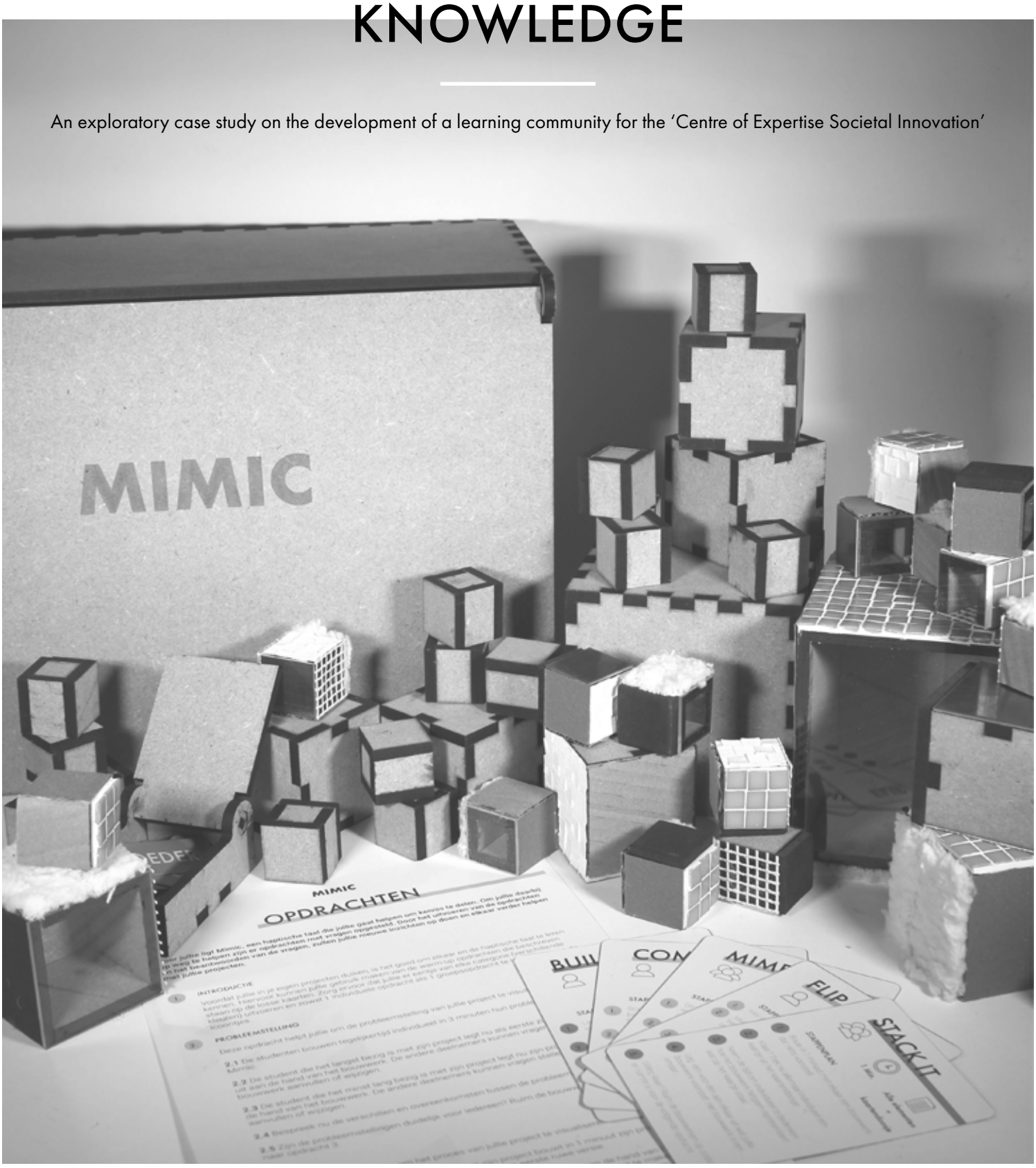
Master thesis by Jolien Sillekens

A HAPTIC LANGUAGE DESIGN TO ENHANCE THE TRANSFER OF TACIT KNOWLEDGE

An exploratory case study on the development of a learning community for the 'Centre of Expertise Societal Innovation'



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Author

Jolien Sillekens
MSc. Strategic Product Design &
MSc. Communication Design for Innovation

Supervisory team

Strategic Product Design

Chair
Dr. Maarten Wijntjes
Associate professor
Human-Centered Design
M.W.A.Wijntjes@tudelft.nl

Mentor
Katrina Heijne
Lecturer
Design, Organisation and Strategy
K.G.Heijne@tudelft.nl

Delft University of Technology
Faculty of Industrial Design Engineering
Landbergstraat 15,
2628 CE, Delft
The Netherlands

Communication Design for Innovation

Chair
Dr. Maarten van der Sanden
Associate professor
Science Communication
M.C.A.vanderSanden@tudelft.nl

Mentor
Dr. Éva Kalmár
Lecturer
Science Communication
E.Kalmar-1@tudelft.nl

Delft University of Technology
Faculty of Applied Sciences
Lorentzweg 1,
2628 CJ, Delft
The Netherlands

May 2021
Rotterdam

Preface

Dear reader,

With this thesis, I will complete my years of studying at the Delft University of Technology and obtain a double degree in the masters Strategic Product Design and Communication Design for Innovation. Combining both subjects into one final project feels like the perfect way to finish this chapter of my life. It was the most challenging yet most instructive project of my academic career. With pride, I present to you my haptic language design for transdisciplinary learning. This result would not have been possible without the support from my surroundings. Hence, I would like to thank the following people that made this project possible.

First, I want to thank Maarten van der Sanden who has encouraged me to take on this pioneering project. You have challenged me every meeting with new perspectives and critical notes and helped me to take the project to the next level. In addition, I would like to thank the rest of my supervisory team, Éva Kalmár, Maarten Wijntjes, and Katrina Heijne. Éva thank you for all your support and advice in doing social research, I finally start to understand how it works. Maarten, thank you for your creative input and eye for detail, I feel a bit like a product designer at the end of this project. Katrina, thank you for your practical feedback, keeping me on the right track, and sensing when I needed a pep talk, I feel ready to take on the next challenge. All the meetings and discussions we had together online are very much appreciated.

Then, I would like to thank Elma Oosthoek, Angela van der Heijden, and Jan Poot from the Centre of Expertise Societal Innovation for daring to take on this challenging project with me. Thank you for allowing me to graduate at such a dynamic and lively organization. You have encouraged me to stop thinking and start doing, but also to have fun. Thank you for your comments and input. And thank you to all the other (former) graduate students of Urban Innovation for your help and inspiration during this project.

At last, I want to thank my friends and family and especially my boyfriend who I am grateful to support me in every possible way in this long graduation journey. Thank you for reading and correcting my thesis, for your input during sessions or interviews, for all your mental support and encouragement, and for making me think of other things from time to time.

Jolien Sillekens

Executive summary

Collaborations are often transdisciplinary whereby people with different backgrounds need to be able to work together and therefore share knowledge. This means people have to cross knowledge boundaries. Crossing these boundaries can be done with boundary objects that help to transfer knowledge across these boundaries (Carlile, 2002, 2004). Touch can expand the vocabulary that people have at their disposal and therefore contribute to making transferring experiential knowledge and crossing boundaries easier.

To make the research of how touch can be applied to enhance transdisciplinary learning more concrete, a specific context has been chosen, namely the organization 'Centre of Expertise Societal Innovation'. Within this organization, they want to create learning communities whereby knowledge is shared and preserved between students and others stakeholders. Therefore, they want to work with consecutive projects. Within this transition of projects between students, a gap was identified whereby knowledge gets lost. To close the gap, a haptic language design based on touch will be developed and tested.

This has led to the following research questions for this master thesis:

"How to improve the transition between graduation projects within the Urban Innovation program of EMI with a haptic language design to preserve knowledge within the different communities of practice."

From the literature, it became known that the knowledge that the organization wants to preserve is so-called tacit knowledge. Tacit knowledge is hard to express in words. Therefore, guidance is needed to help people express their tacit knowledge. From the theory of transdisciplinary learning, it is retrieved that the 7 habits of the mind are important to foster transdisciplinary learning. These habits also include using the senses of the human body. Therefore, it is interesting to combine transdisciplinary learning by expressing tacit knowledge with the senses of the human body. Especially the sense of touch is interesting to use because touch can deepen communication and is one of the most versatile senses.

Touch can be experienced throughout the whole body, but our hands are the most sensitive to touch. The dimensions that can be retrieved from touch are texture, hardness, temperature, shape, volume, and weight. These dimensions all have their exploratory procedure, a specific hand movement, to explore them. The dimensions weight, temperature, and texture are the most important when designing for touch.

Combining the literature study with exploratory research on how touch can be used in communication and a prototype design that has been tested, has resulted in 6 haptic design principles for transdisciplinary learning. These principles can be used by designers that want to create physical haptic designs for transdisciplinary learning. The 6 haptic principles are:

1. Haptic design triggers people to touch it
2. Haptic design makes people conscious of touch
3. Haptic design enables different touch experiences
4. Haptic design translates and adjusts between different disciplines by providing the same meaning for everyone
5. Haptic design evokes interaction between users
6. Haptic design gives people the tools to make their thoughts and ideas tangible

With the principles, a final concept design has been created, called **MIMIC**. MIMIC is a haptic language design that helps users to express their internal thoughts, ideas, and feelings by providing tools to make these internal thoughts, ideas, and feelings tangible. Translating to external forms will make it easier for others to understand. MIMIC consists out of two sets of cubes, the basic set made of wooden cubes with different weights, and the haptic set of cubes with different materials from 10 categories on each side cubes. Furthermore, a guide, an instruction sheet, and warming-up exercises are created to give guidance to users for sharing relevant knowledge and the use of the haptic language in general.

Glossary

Abbreviation	Meaning
CoP	Communities of Practice
EMI	Centre of Expertise Societal Innovation
HD	Haptic Design
HR	Hogeschool Rotterdam
SLS	Social Learning System
UI	Urban Innovation program

Community of Practice
A group of people that share a common interest in a topic, a passion or a problem who come together regularly to interact and exchange ideas and knowledge.

Experiential knowledge
Knowledge that we have obtained from our experiences.

Haptics
Any form of interaction involving touch.

Haptic language design
A tool based on communicating with touch.

Haptic perception
The process of recognizing objects through touch.

Learning community
An environment in which people learn from and with each other and additionally create new connections between people and, therefore, knowledge can take root.

Transdisciplinary learning
Interacting about a relevant concept or problem by integrating different perspectives of multiple disciplines in order to share knowledge and create new knowledge.

Tacit knowledge
Knowledge that resides in people's heads and can hardly be expressed in words. It refers to things we know but are not able to verbally communicate to others. (Sanders & Stappers, 2018)

U-shaped learning curve
Refers to the learning curve that Elma Oosthoek has developed for the program Urban Innovation based on theory-U of Otto Scharmer.

Urban Innovation
Refers to the program Urban Innovation of the Centre of Expertise Societal Innovation. It is one of the five programs of EMI. The program focusses on solving urban issues in the south of Rotterdam.

Reading guide

For a quick read
Retrieve the most important insights by reading the table of contents, the opening of every chapter and the key takeaways.

Figure 0. An example of how a chapter begins and ends

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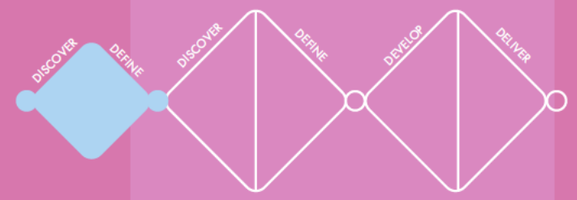
PROJECT INTRODUCTION



CHAPTER 1

1.1 Company introduction

In the south of Rotterdam, the living conditions are not comparable to those in the rest of the city. The area lacks behind and struggles with high unemployment, poverty, a low education level, and low housing value (Deetman, 2011). Therefore, the residents of this area have suffered great social and economic disadvantages. A lot of children leave school without a diploma and a language delay. The houses in the south of Rotterdam are outdated and the joint outdoor space leaves something to be desired. To improve the living conditions in the south of Rotterdam, EMI, Centre of Expertise Societal Innovation, has been established to connect education and research with complex societal problems in the south of Rotterdam to solve them (Wat is EMI?, n.d.).

EMI has been established in cooperation with Hogeschool Rotterdam (HR). EMI has a widespread network with practical partners, researchers, the municipality, and people working in the different neighborhoods of the south of Rotterdam and HR brings in motivated students from different disciplines. Involving students for solving the complex problems in the south of Rotterdam should lead to graduates who want to live and work in the area, so they can continue to improve the south of Rotterdam. EMI can be seen as the 'liaison officer' that brings the students into contact with partners in its network for collaborations in so-called communities of practice (CoP) (Wat is EMI?, n.d.). CoPs consist of people in practice and research that interact with each other about a common interest. These CoPs are formed around the five different program lines of EMI that all represent a different focus:

1. Education
2. Work
3. Care & Welfare
4. Urban Innovation
5. Art & Culture

Within the different program lines, EMI works together with their network and the students to improve income level, care, education, and living conditions. In Figure 1 an overview of the network of EMI can be seen and the interactions between all of its partners, including HR.

This Figure shows a snapshot of the network because the network is still expanding.

The CoPs per program line consist of students, lecturers, researchers, and practical partners. Within the CoPs, reciprocal learning is central (Wat is EMI?, n.d.). The idea of reciprocal learning is that members of the CoP learn from and with each other and offer the south of Rotterdam new knowledge and solutions that expand opportunities and reduce inequality for the residents in the area (Wat is EMI?, n.d.).

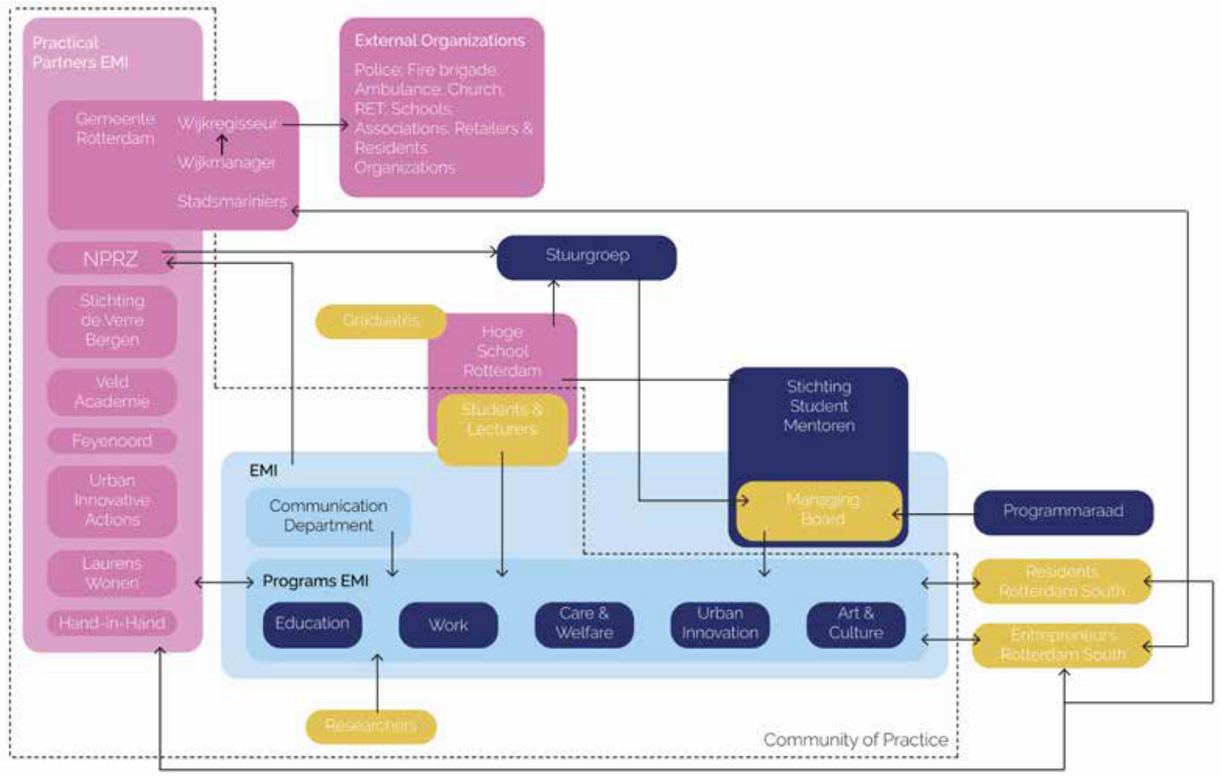


Figure 1. Stakeholder network EMI

1.2 A Closer look at the program Urban Innovation

Urban Innovation (UI), one of the five program lines of EMI, has recently started with establishing a learning community in which reciprocal learning is key. UI works on complex urban problems in the different neighborhoods of Rotterdam South, for example, the energy transition that requires households to get rid of gas. These complex urban problems have many dimensions, stakes, and stakeholders, whereby the neighborhood resident often is a respondent instead of an interlocutor (E. Oosthoek, personal communication, 17 September 2020). The residents do not feel heard, so the willingness to cooperate falls. However, the residents are needed to solve the problems and therefore, UI tries to integrate the residents in the complex urban problems via its network and the students of HR and make them an interlocutor.

For this integration, UI found it important that the students, lecturers, residents, and other professionals work together within the environment in which the urban problems occur. Therefore, UI has established the 'Wijkstudio' in 'Het Huis van de Wijk' in the heart of the neighborhood Hillesluis where people can learn from and with each other in close collaborations. These collaborations form around different types of student projects, from minor to graduation projects. UI tries to make the student projects consecutive and to always involve the residents. Because this creates a long-term presence, mutual trust between de residents and other stakeholders arises.

The different stakeholders working together fits with the idea of the learning community that is based on reciprocal learning, which means learning from and with each other. The goal of this learning together is that new social connections arise between people, which leads to a stronger social fabric. An environment in which people spend time with each other and additionally new connections are made between people and, therefore, knowledge can take root, is a learning community according to UI. This approach should not only lead to reciprocal learning but also to equal learning for the residents that collaborate but often do not take advantage of the results (Urban Innovation, n.d.). What also contributes to this reciprocal and equal learning is the neighborhood- and people-oriented approach that the students and other stakeholders apply in the vicinity of the target group.

To help students and lecturers with the strong participative method described above, Elma Oosthoek, intervention director UI, has created a learning curve (see Figure 2). The U-shaped learning curve is based on Theory-U from Otto Scharmer and offers a way to create continuous participation from the start until the solution of a complex urban problem. The start of the learning curve is a decision, i.e., are you going to solve the complex urban issues by doing it as you used to (blue route), or are you willing to open yourself up for the unknown (yellow route). The yellow route is about listening to the residents and learning with them (physically close), letting have residents a say and building trust (mentally close), and, finally, learning and creating together in a community (Oosthoek, 2020). The yellow route is the preferred situation for UI because this route establishes new social connections. Therefore, the students are encouraged and coached to follow this process. The learning curve is the way of working within the CoP of UI.

Building the learning community of UI based on the learning curve of Elma Oosthoek started in 2020 and, therefore, still is a very new concept and so is the current management of the program that started in 2019. The learning community of UI is still in the start-up phase, but the added value of the learning community is already noticed. Students indicate that they feel more involved in urban issues, lecturers notice an increase in environmental sensitivity among students, residents, and entrepreneurs feel that they are taken more seriously, and practical partners appreciate the proximity of the students.

In 2021 the focus of UI will be on 2 strategic themes from HR, being the economy of meaning and sustainability (Emi op Zuid, 2021). Another goal for 2021 is to make the impact of working in learning communities around the themes economy of meaning and sustainability even more tangible (Emi op Zuid, 2021) by:

- Learning to move between various interests in complex issues
- Multidisciplinary learning, implicit learning (reflection), and the development of transformative competences
- Strengthening mutual participation, the social fabric of the city, and the development of a learning attitude in the neighborhoods.

The idea behind the experimental practical learning from the strategic agenda of HR is that in the long-term UI becomes superfluous and that the institutes can take over its work together with the residents and other important stakeholders (Emi op Zuid, 2021).

1.2.1 Graduation at the program Urban Innovation

Within the two different themes mentioned above, minor and graduation students are working on a variety of projects. At this moment, some second-generation and some third-generation graduates are working within the learning community at the 'Wijkstudio', meaning they are the second and third group that will graduate within the learning community of UI. Via interviews with the first-generation graduates, a survey conducted with second-generation graduates (appendix A), observations of conversations between UI and third-generation graduates, and conversations with the management of UI, a detailed understanding of the current graduation process has been established. A better understanding of the current processes of UI can help to uncover problems and points of improvement within the learning community.

Before the start of the graduation project, students need to connect with UI. How and when this connection with UI is made, differs per student.

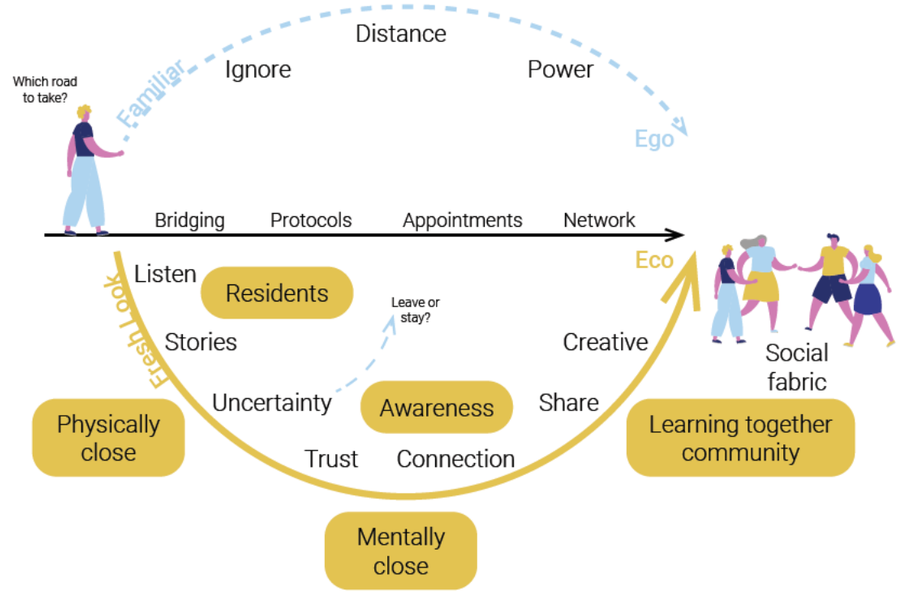


Figure 2. U-shaped learning curve retrieved from E. Oosthoek (2020)

Some come in via lecturers of their studies, others through EMI's network, and again others via an online search. Some start very early with finding a spot for graduation, where others come in just before the start of their graduation.

After he or she has shown interest in UI, the student will have a conversation with the management of UI whereby the management tries to match the interest of the student with a complex urban problem of the south of Rotterdam. This can be a problem that is new for UI or a consecutive project for a problem that is already known and addressed. The ideal situation for the learning community is that most projects are consecutive because the problems they are dealing with are too big to tackle in just a single project and the knowledge that is gained can be passed on to the new graduate student. At the moment this is not often realized because the learning community of UI is still in its start-up phase.

After the student is matched with a topic, the student, in cooperation with the management of UI, will formulate a research question and a project brief. The students will work for a problem owner that can be a practical partner of EMI, a specific target group, or the management of UI. Now the student can start his/her graduation. The start of the graduation is in either September or February. This means that every six months a new group of graduate students will start graduation at UI.

Just like the initiation of the graduation process, also the ending differs per student. Usually, the graduation process ends with handing in a report and a presentation. These presentation moments for HR take place at different times. Furthermore, some students might need to do an additional assignment which makes their graduation period longer. These different courses of events make UI a dynamic environment and difficult to pour into a solid structure.

1.2.2 Communities of Practice within the program Urban Innovation

As stated in paragraph 1.1, the introduction of EMI, around each program line a community of practice (CoP) exists consisting of the management of the program, students, lecturers, researchers, and practical partners. UI is a CoP on its own, but within UI 2 smaller CoPs are being created around the two strategic themes of HR, i.e. economy of meaning and sustainability. These CoPs are the learning communities in which new connections are made to root knowledge. The management of UI is the overarching party of these two CoPs, see Figure 3.

When a student has been matched with a complex urban problem, he/she will form a team within one of the CoPs, with the problem owner, the supervisor of the student, and the management of UI. Sometimes the target group and researchers are included as well, depending on their role within the project.

When the problem is new, a new team is formed. When the student will follow up on a project, the student with his supervisor will enter an existing team and the former graduate and his supervisor will leave the team, see Figure 3. When there is no follow-up project, the team that was formed will most likely disappear because the former graduate will leave UI. Therefore, every six months, teams are formed, changed, or discontinued within the two CoPs.

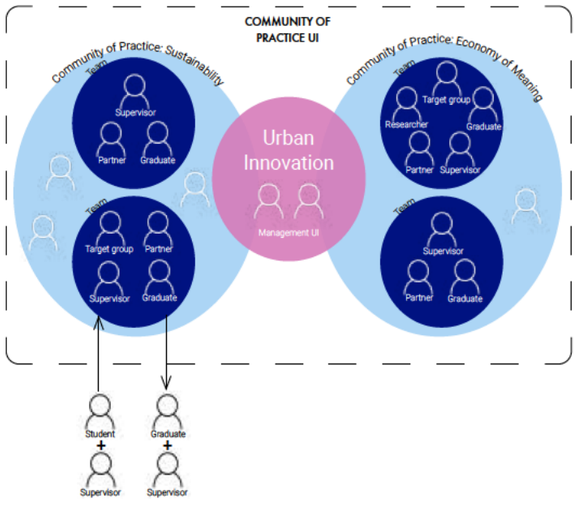


Figure 3. Communities of Practice of the program Urban Innovation

1.3 Problem Introduction

As stated in the introduction of UI, forming the learning community of UI is still in the start-up phase and the environment around UI is very dynamic and, therefore, difficult to manage and structure. Not only students come in from all different kinds of studies, but also new complex urban problems arise and the network of UI keeps expanding with new practical partners and other parties that want to be involved. Managing all these different factors requires time and flexibility. A consequence of this is that processes are not yet structured and need to be developed over time. This is especially the case within the graduation projects for which no structure from UI is provided and, therefore, is the focus of this master thesis. The minor projects are managed by HR and have a provided structure; therefore, they are not in the scope of this master thesis.

The reason that UI wants to form a learning community is that knowledge can be preserved and built upon. Therefore, it is not only important that projects follow up on each other, but also that there is a plan on how knowledge is preserved within the CoP. From personal interviews with first-generation graduates, it was noted that at this moment graduates do not know what happens with their results and if anyone else will continue their work:

"I think Juliette would continue with that, but in a different way. Not the platform anymore, but the same subject, something in that direction. She had to read my graduation report and we had a video call wherein she asked questions. So, I assume that she will continue in one way or another." (Aida Ausum, personal communication, October 9, 2020)

"I don't know if anyone has taken my concept any further." (Monique Wiersma, personal communication, October 13, 2020)

A gap is identified between graduation projects causing knowledge to get lost easily. This knowledge is mostly experiential knowledge that is not written down in the reports the graduates deliver. While there were some activities planned and done around the transition of the graduation project of Aida Ausum, this was not the case for other projects. At the moment there is no clear idea from the management of UI on how it wants to preserve the knowledge and transfer the knowledge between projects. This is done on the initiative of the students if it is done at all. In the preferred situation, this gap is closed by creating overlap between the different graduation projects. This overlap or transition period helps to transfer and preserve more knowledge within the different CoPs. This is visualized in Figure 4.

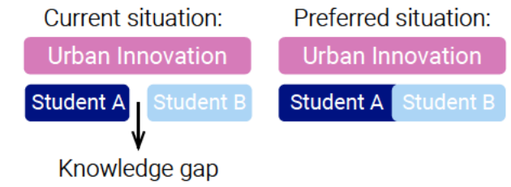


Figure 4. Transition between graduation projects

This situation of experiential knowledge going lost in the CoPs is also confirmed with the results of the survey that was conducted among six second-generation graduates, as shown in Figure 5. Only 2 out of the 6 graduates work on a consecutive project and have spoken to former graduates before the start of their graduation. Only one of these two graduates stated that the goal of this conversation was to get information and help for forming the research question. The other student explained that the conversation with the former graduate was to outline expectations. The experiential knowledge that the former graduates gained within their graduation for UI does not seem to be transferred to the new graduates, or at least very inefficiently.

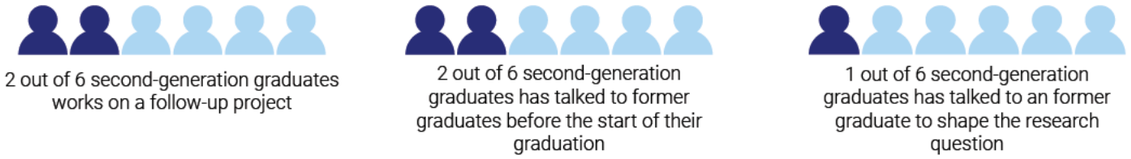


Figure 5. Results survey second-generation graduates

To conclude, the problem that has been found within UI is the gap that exists between graduation projects. Only two projects seem to have a continuation and there is little contact between old and new graduates. If UI wants to build a strong learning community, it is necessary to close the gap between different generations of graduates, their projects, and the corresponding CoP. The gap also shows that the requirements for establishing a CoP are not met. There are almost no joint activities and there is no shared repertoire. To establish a CoP and, therefore, a learning community, it is not only important to close the gap but to also include joint activities and a shared repertoire.

Closing the gap between graduation projects means dealing with boundaries. Every CoP has its own boundaries when it comes down to knowledge and experience. When a new student enters the CoP and forms a team with people from that CoP, the student and the rest of the members need to come together to collaborate. Common knowledge is needed to gain a shared understanding and, therefore, 'knowledge boundaries' have to be crossed. Crossing these boundaries can be done with boundary objects that help to transfer knowledge across these boundaries (Carlile, 2002, 2004). A boundary object can help to close the gap between the graduation projects, can contribute to joint activities, and is part of a shared repertoire.

With VormTaal by Anne Kamp (2018), it was found that a 3D abstract language can help to create an understanding of complex social problems and can, therefore, function as a boundary object. This language is based on architecture and the sense of sight. From the perspective of communication, it is interesting to research if the sense of touch can add another level of communication to the abstract language. Touch uses different connections in our brain and can deepen experiences. Touch can expand the vocabulary that people have at their disposal and therefore contribute to making transferring experiential knowledge and crossing boundaries easier. The idea of this master thesis is to research if and how touch can be integrated into an abstract language like VormTaal to enhance the quality of interaction and contribute to transferring experiential knowledge. In the next chapters, this theoretical framework is explained in more detail.

The identified problem and solution direction lead to the following research question:

"How to improve the transition between graduation projects within the Urban Innovation program of EMI with a haptic language design to preserve knowledge within the different communities of practice."

This research question leads to the following sub-questions:

1. How can knowledge be transferred between people?
2. What is 'Haptic design'?
3. What are the principles for a haptic design that can enhance communication between people?
4. Which knowledge needs to be transferred with the haptic language design for Urban Innovation?
5. How can haptic design principles be translated into a physical haptic language design?
6. How do graduate students of Urban Innovation experience the use of a haptic language design when discussing their projects?

In general, the case of UI describes a learning environment whereby different disciplines need to come together to make knowledge transfer possible. Therefore, the results of this master thesis can be applied in different contexts wherein transdisciplinary learning is happening and knowledge needs to be shared. More about the value of the final concept design can be found in chapter 7.5.

1.4 Project approach

This paragraph describes the research approach and the methods that were used to develop haptic principles for transdisciplinary learning and a concept design for a haptic language. The exploratory character of the research asked for a flexible approach to cope with unforeseen discoveries and to redirect the project when necessary. This included critical reflection moments on outcomes and incorporating these into the next steps of the design process.

The approach of this master thesis followed the double diamond model constructed by the Design Council UK (2005) combined with design-based research by Amiel & Reeves (2008). The double diamond model divides the design process into four different phases: discover, define, develop, and deliver. The diverging and converging phases provide guidance for the execution of a design process. The design-based research approach follows this design process with four phases:

1. Analysis of the practical problem(s);
2. Development of solutions based on existing design principles and technological innovations;
3. Iterative cycles of testing and refinement of solutions in practice, and
4. Reflection on the procedure, "design principles" and enhancement of solution implementation.

In Figure 6 an overview of the project approach can be found. Before the start of the design-based research, an extra diamond covering the discover and define phase has been performed to create a better understanding of the challenges that Urban Innovation faces. After the problem statement was defined, a full double diamond was performed in combination with the design-based research cycle to develop a prototype, conduct a prototype test, reflect on the results and create design principles and a final concept design.

1.4.1 Methods

First, a discover phase and a define phase were performed to determine the problem that could potentially be solved with a haptic language design. To that end, four semi-structured interviews were performed with former graduate students to get an idea of how the organization and the graduation processes work. Besides, a survey was held with current graduate students to get an idea of how many contacts the graduation students had at the beginning of their projects and with whom. Finally, observations were performed of conversations between managers and potential new graduates to get a better understanding of the transition phase between graduation projects. The interviews, the survey, and the observations have led to a clear problem statement (see paragraph 1.3).

After the problem statement had been defined, a literature study was performed to establish a theoretical framework. The theoretical framework consists of two parts. The first part is a theoretical background to get a better understanding of the context in which the haptic language will be used. This framework consists of the main concepts of communities of practice, transdisciplinary learning, and tacit knowledge transfer. The second part focused on getting insight into what haptics includes. This theoretical part consists of a description of the different sensors in the human body, how haptics is perceived by humans and how other senses influence haptics. Both parts of the theoretical framework were used as a basis for developing a haptic prototype and establishing haptic design principles.

First literature on communities of practice was used to get a better understanding of the working principles within the organization Centre of expertise societal innovation (EMI). From this concept, it was retrieved that transdisciplinary learning should be established. Using this as a starting point, additional literature was explored using a snowball search and Google Scholar. On Google Scholar literature was found using the keywords "transdisciplinary" and "transdisciplinary learning".

Furthermore, literature was searched using the keywords "knowledge boundaries", "knowledge boundary-crossing" and "boundary objects" to understand how transdisciplinary learning in organizations can be established. Articles that were used had references to one or more of the key theories. To complete the theory on the context of the organization, literature research with keywords

"transferring knowledge" and "tacit knowledge" was performed to get a clear idea of how this specific knowledge can be shared and persevered in EMI. Chapter 2 describes the theoretical background and concludes with the most important points to take into account for the final design, retrieved from the theory.

Second, literature research on haptics was performed to get an understanding of how haptics works and what haptics entails. Literature has been searched on Google Scholar with the keywords "haptics" and "haptic design". Furthermore, literature was retrieved from Visio, an institute for the blind in the Netherlands. The theoretical background on haptics is described in Chapter 3 and concludes with design takeaways.

After the literature study, two exploratory tests have been executed to get insight into how haptics could be used in the communication of complex urban problems. Furthermore, a creative session has been performed with peers to get a broader understanding of how haptics could be used as a means of communication. The tests and the creative session with their conclusions are described in Chapter 4.

The two exploratory tests and theoretical framework resulted in a prototype design that was tested in two workshops. The workshops simulated a transition of consecutive projects between two graduate students. The prototype was tested with graduate students of UI. The main goal of the test was to get insights into the role of haptics in communication and to gather input for the development of design principles. The sub-goal of the test was to get an indication if the graduate students of UI and the management would find it useful to work with such a language and if it indeed could transfer the right type of knowledge. The results of the prototype test have been interpreted and reflected on through an observation list based on the theoretical framework. The prototype design and the test results are described in Chapter 5. This chapter concludes with design takeaways.

With the interpreted results in combination with the theory and the results from the exploratory tests, 6 haptic design principles for transdisciplinary learning are proposed and described in Chapter 6. All conclusions and design takeaways together with the principles are synthesized into a final concept design described in Chapter 7.

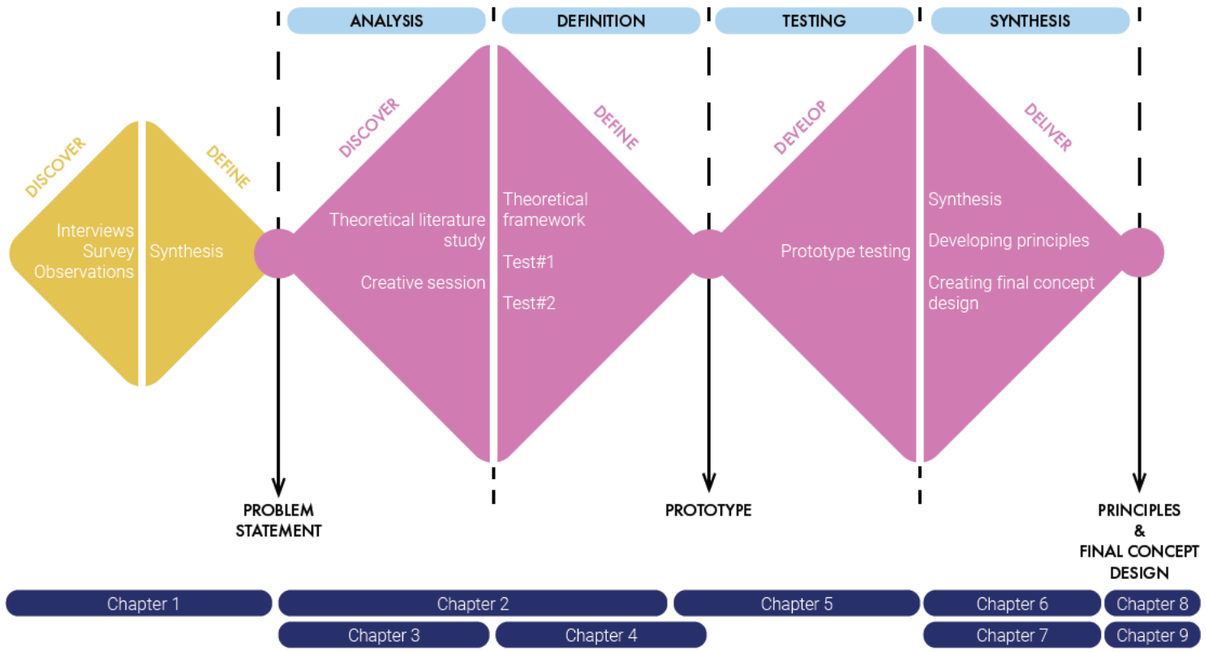


Figure 6. Visualisation of the project approach (inspired by Amiel & Reeves, 2008; Design Council, 2005)

CHAPTER 1

KEY TAKEAWAYS

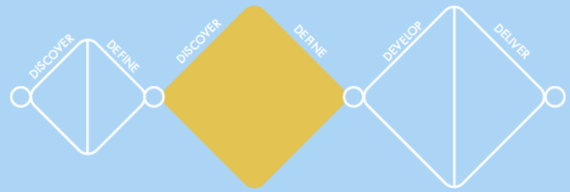
Collaborations are often transdisciplinary whereby people with different backgrounds need to be able to work together and therefore share knowledge. This means people have to cross knowledge boundaries. Crossing these boundaries can be done with boundary objects that help to transfer knowledge across these boundaries (Carlile, 2002, 2004). Touch can expand the vocabulary that people have at their disposal and therefore contribute to making transferring experiential knowledge and crossing boundaries easier

To make the research of how touch can be applied to enhance transdisciplinary learning more concrete, a specific context has been chosen, namely the organization 'Centre of Expertise Societal Innovation'. Within this organization, they want to create learning communities whereby knowledge is shared and preserved between students and others stakeholders. Therefore, they want to work with consecutive projects. Within this transition of projects between students, a gap was identified whereby knowledge gets lost. To close the gap, a haptic language design based on touch will be developed and tested.

This has led to the following research questions for this master thesis:

"How to improve the transition between graduation projects within the Urban Innovation program of EMI with a haptic language design to preserve knowledge within the different communities of practice."

THEORETICAL FRAMEWORK



CHAPTER 2

The learning communities of UI can be related to the situated learning theory of Lave and Wenger (1991). Situated learning is a model of learning in a so-called community of practice (CoP). Lave and Wenger (1991) argue that learning is a social process in which knowledge is co-constructed. Such learning takes place in a specific context and is embedded within a particular social and physical environment. Lave and Wenger call this a process of "legitimate peripheral participation". Social interaction and collaboration are essential components of situated learning. Situated learning was further developed by Wenger into social learning systems.

Based on this idea of social learning, a theoretical framework is built that looks into how learning takes place within the two learning communities of UI. The framework will start with a broader view on the situation of UI as social learning system (see chapter 2.1) and the communities of practice they want to establish (see chapter 2.2). Then a closer look into the way that members in the learning communities learn from and with each other is given with a focus on transdisciplinary learning (see chapter 2.3), crossing boundaries (see chapter 2.4) boundary objects (see chapter 2.5), and tacit knowledge (see chapter 2.6). At the end of the chapter, an operationalization table is added to give an overview of the most important concepts of the theoretical framework.

2.1 Social Learning Systems

The idea behind social learning systems is that learning is not a linear process, but relies on people's interactions with others. In such a system knowledge is not transferred (linear) but created together. According to Wenger (2000), for understanding a social learning system it is important to have a social definition of learning. The social definition of learning is defined as an interplay between social competence and personal experience. Social competence means what it takes to act and be recognized as a competent member of a community. Personal experience means the experiences that people have in their world in the context of a given community and beyond. Whenever these two are in tension and either starts pulling the other, learning takes place. If they are too disconnected or the distance is too large, learning is not likely to take place. (Wenger, 2000)

According to Wenger (1998), social learning systems have three structuring elements, 1. Communities of practice (CoP) that are the basic building blocks of social learning systems; 2. Boundary processes among these CoPs, and 3. Identities shaped by participation in the systems. To sustain these structuring elements and to make sure a community of practice functions, four key concepts need to be in place. The first concept is that a CoP needs to be formed around a shared concern or interest for a certain topic.

The second concept is that there are three modes of belonging that indicate that someone participates in a social learning system. The three modes of belonging are (Wenger, 2000):

1. Engagement means doing things together like talking or attending a meeting.
2. Imagination means that people construct an image of the world to help them understand how they belong to that world and to reflect on their situation like building scenarios to understand one's options.
3. Alignment means making sure that activities align with other processes such that they can be effective beyond people's engagement like coordinating activities and following the laws.

These three modes usually coexist and every social learning system involves each of them to some degree and in some combination (Wenger, 2000).
The third concept is that other elements also influence the dynamics and functioning of a CoP, for example, leadership or the communication between members in a community. Finally, the fourth concept is that boundaries are essential to social learning systems because creative tension at boundaries of CoPs offers distinct learning opportunities that are different from those offered by communities. The first concept of creating a CoP is explained in more detail in chapter 2.2, the fourth concept of boundaries is explained in more detail in chapters 2.4 and 2.5.

Within the context of this graduation project, the overarching community of practice around Urban Innovation is seen as a social learning system, because learning is established in interactions with others. Within this social learning system, engagement and imagination are important modes of belonging. Opportunities need to be created for joint activities between students that are members of the CoPs within UI. The joint activities can establish interactions whereby boundaries are crossed and knowledge is shared, created, and preserved.

2.2 Communities of Practice

A community of practice (CoP) is a group of people who share a concern or interest for a certain topic and they deepen their knowledge and expertise through regular interaction whereby they share information, insights, experience, and tools related to their common concern or common interest (Wenger, McDermott & Snyder, 2002). The members of the CoP engage in a process of collective learning. The CoP can, therefore, also be seen as a learning community.

According to Wenger-Trayner & Wenger-Trayner (n.d.), there is a difference between a community of practice and a team. A team is held together by a task. When the task is accomplished, the team disintegrates. A community of practice is held together by the 'learning value' that members find in their interactions. They may perform tasks together, but these tasks do not define the community. It is the ongoing learning that keeps the members committed. Therefore, the distinction between CoPs and teams was made earlier (see chapter 1.2.2). In the previous chapter, it was also explained that within Urban Innovation two CoPs exist around the theme's sustainability and economy of meaning (see also Figure 3). These CoPs will keep existing even when students graduate and leave because the ongoing learning is what keeps them together and new students will enter. Around a graduation project, the student and some members of the CoP form a team, because their goal is to solve a smaller problem, which can be seen as a task. When this task is accomplished, their ways will part but within the CoPs, new teams will be formed around new tasks that need to be fulfilled.

The definition of community of practice is further explained by three structuring elements that create a CoP (Wenger-Trayner et al., 2015; Iverson and McPhee, 2008). The first element is the domain of interest that is shared among the members of the community and that defines the identity. CoP membership does not only indicate interest in a certain topic but also a commitment to the topic and expertise that is shared among members. The interest in, commitment to, and expertise in the topic distinguish members from other people. The second element is the community, i.e., members engage in joint activities and discussions, help each other and share information. During these activities and discussions, relationships are built between members that enable them to learn from each other. The third element is the practice, i.e., members develop a shared repertoire of resources to use within the community. They actively test ideas, usually through a shared set of resources, e.g., experiences, tools, metaphors, and ways of addressing recurring problems, in ways that enable them to do things better. Developing this sort of shared practice takes time, trust, and sustained interaction.

Looking at this definition of CoPs and the analyses of UI, one can state that UI wants to be a CoP around the broad domain of urban issues in the south of Rotterdam, but that it is still developing this CoP. Not all elements that create and sustain a CoP are met yet. As explained in chapter 1.2, in the coming year the focus of UI will be on the two themes sustainability and economy of meaning. Around these two themes, UI wants to build learning communities that can be seen as CoPs with the two themes as the shared domains of interest. This would mean that the first element that creates a CoP is implemented.

The second element that Wenger-Trayner et al. (2015) describe, the joint activities, is gaining presence in UI as CoP. UI is involved in meetings in which different members have discussions around urban issues in the south of Rotterdam as well as residents' meetings. It also organizes meet-ups with all graduates in the so-called 'Wijkstudio' to share insights and to stimulate interaction. However, from the personal interviews and the survey, it was found that most students only speak to other members in 1-on-1 conversations. Therefore, while there are interactions between multiple members of the community, the students do not seem to be involved. The students rarely interact in joint activities with members of the CoP. It is a point of attention to include the students in interactions with multiple members of the CoP to make them full members.

The third element, a shared practice, is not in place for UI as CoP or the smaller CoPs. Graduate students sometimes use tools like sketches to communicate with other members in the CoP (see Appendix A), but often this is only done with a specific subgroup of members like the target group. The students do not use them in communication with other members of the CoP or in joint activities at which multiple members are present. Therefore, these tools cannot be considered as a shared practice. This means that a shared practice still needs to be developed to create a full-fledged CoP.

In conclusion, to establish full-fledged CoPs within UI, the second element of joint activities and the third element of a shared practice need to be realized. The proposed haptic language can be a tool for discussing the complex social problem that the graduates will work on in a joint setting with the members with whom they have formed a team within the CoP. In this respect, the haptic language creates a joint activity and the first tool in a shared repertoire and, therefore, helps to build the CoPs.

2.3 Transdisciplinary Learning

By sharing information, insights, experience, and tools related to the area of common interest, the members of the CoP deepen their knowledge and expertise or, in other words, learn from each other. Within the situation of UI, the shared domain of interest is complex urban problems that are tackled by members from all different kinds of disciplines. To tackle these problems there is a need for new knowledge. As Park & Son (2010) describe, transdisciplinary learning is driven by the need for new knowledge creation to address complex problems of humanity. The learning that takes place within the CoPs can be seen as transdisciplinary learning.

Transdisciplinary learning is the exploration of a relevant issue or problem that integrates perspectives of multiple disciplines and sectors to connect new knowledge and deeper understanding to real-life experiences (Kompar, 2009). It is an iterative process that transforms and transcends initial knowledge into merged knowledge (McGregor, 2017). In other words, different stakeholders collaborate and learn together to solve complex social problems, and this is what happens in the CoPs of UI.

To reach transdisciplinary learning, Müller, Tjallingii & Canters (2005) propose a three-step learning cycle (see Figure 7), that helps people from different disciplines and sectors to work together to establish a shared understanding of a certain problem. Learning occurs through continuous interactions between internal interpretations and external actions. The three steps involved are normative, creative, and descriptive. The normative step describes that members have their own purpose, concepts, knowledge, and interpretations of the world. It is a translation from information to purpose. The creative step describes that members informed by their internal perspectives pose actions. These actions have a series of expected and unexpected effects. It is the translation from the internal world of thoughts and feelings to the external world of forms. The descriptive step describes that the actions and consequences of the creative step are observed and described by each member. This leads to different viewpoints that inspire the creation of new knowledge, ideas, and concepts. It is a translation from the external world to the internal world. The interpretation of the shared data, the personal view on the problem, the chosen approach, and possible solutions can shift which can lead to new ideas, and as such the transdisciplinary learning cycle continues.

The three-step learning cycle from Müller et al. (2005) can be applied to the situation of transferring knowledge between former and new graduates within the different CoPs. The former graduate has gone through a graduation process and has come up with results (the creative step). These results are made explicit in a report, the descriptive step. However, the experiential knowledge that comes from the internal world of the former graduate is not yet made explicit. To make this explicit, it is needed to make it tangible for others. This means the creative step needs to happen to make sharing knowledge possible with the new graduate and other members of the CoP. The new graduate and other members of the CoP will then be able to understand this knowledge (descriptive step) and can create their interpretation of the knowledge in the normative step, which is then the start of a new cycle and the start of the graduation project of the new graduate. Transdisciplinary learning contains both individual learnings as well as group learning.

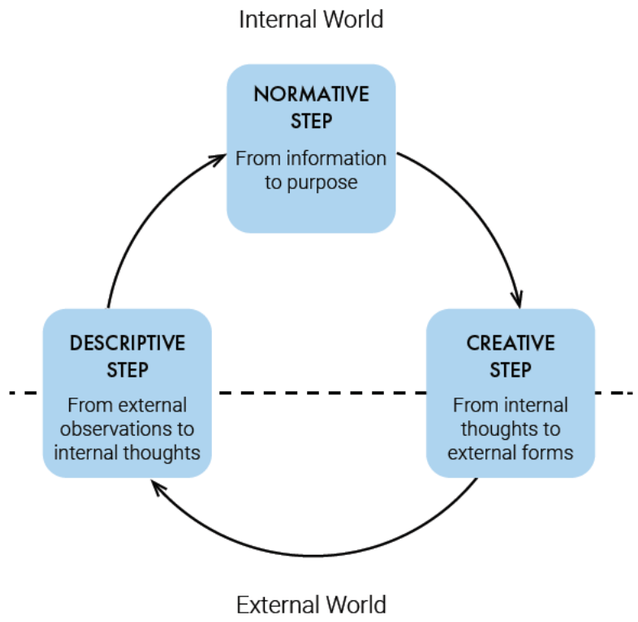


Figure 7. Transdisciplinary learning cycle (Müller, Tjallingii & Canters, 2005)

This individual and group learning can also be seen in the different habits of the mind for transdisciplinary learning that are composed in theory. On the one hand, there is Derry & Fisher (2005) that discuss three mindsets that bring different disciplines and members together (group learning), i.e. knowledge about boundary objects, communities, and metacognitive skills that foster a reflective community. First, knowledge about boundary objects is important because knowledge exchange requires members to come together and to cross boundaries because they all come from different disciplines and different social worlds. To do this, they use boundary objects (see also chapter 2.5) which will help to make ideas understandable across different disciplines. Secondly, transdisciplinary learners need to commit to the collective creation, expansion, and building of knowledge through knowledge creation communities. They need to be able to find common ground, which will enable them to work together to create shared knowledge. Thirdly, transdisciplinary learners must be able to think about and monitor their thinking, in other words, be able to reflect on themselves. This habit of the mind supports a reflective transdisciplinary knowledge creation community.

On the other hand, there is Mishra, Koehler & Henriksen (2011) that discuss seven habits of a transdisciplinary mind, cognitive skills that every individual tends to use when creative thinking across a range of domains (individual learning): observing, patterning, abstracting, embodied thinking, modeling, playing and synthesizing (see Figure 8).

1. Observing is the first step to understand something. It involves close attention to information gathered through the five senses, with intent focus and curiosity (Henriksen, 2016). It goes beyond registering information to notice details and meanings. It can be encouraged with practice and attention to detail. An example of observing is an ornithologist that identifies species by sound.
2. Patterning includes both the act of recognizing patterns and forming them. Recognizing is the analytical part while forming is the creative act (Henriksen, 2016). An example of patterning is the mathematician that relies on patterns in numbers.

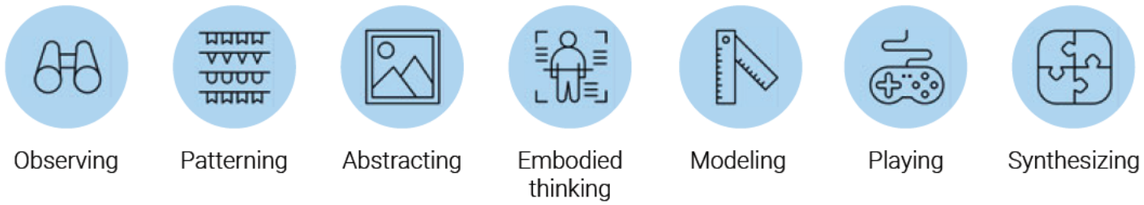


Figure 8. 7 Habits of a transdisciplinary mind (Mishra, Koehler & Henriksen, 2011)

3. Abstracting involves capturing the essential nature of a thing, by concentrating on one feature to boil it down to grasp its essence. Features like color or size can be eliminated to focus on the features of interest. Using analogies is also a form of abstracting.
4. Embodied thinking involves bodily thinking exemplified by sensations and feelings in the body, of movement, balance, tensions, etc. It also involves empathizing, understanding someone else's point of view, feeling what they feel. An example of embodied thinking is an actor that empathizes with a character to portray it authentically.
5. Modeling involves creating a representation of something in real or theoretical terms to study its nature, composition, or purpose. An example of modeling is a designer that creates a sketch.
6. Playing is something that is done for 'fun' but can open new ways of thinking and new insights.
7. Synthesizing is the last step that ties together the previous habits, putting different ways of knowing together into a synthesized whole. When a person fully understands something, feelings, senses, knowledge, and experiences come together in a multi-faceted, cohesive way. A person feels what they know and knows what they feel.

The habits of the mind for transdisciplinary learning indicate that the haptic language design is a reflection tool that helps the group to think about and monitor their thinking. The haptic language design can help the graduate students to reflect on their process. On an individual level, the haptic language design should take the seven habits of a transdisciplinary mind into consideration, because one wants it to enhance transdisciplinary learning within the communities of UI.

2.4 Crossing Boundaries

As explained in the previous sections, within the CoPs of UI members come from different disciplines and different social worlds that create boundaries. One of these boundaries is the 'knowledge boundary'. To establish transdisciplinary learning, interaction needs to take place between these members, and, therefore, these boundaries need to be crossed. Crossing the knowledge boundary will create a shared understanding of the complex urban problem and a basis for collaboration.

Kasl, Marsick, and Dechant (1997) define boundary-crossing as: "(. . .) to seek or give information, views, and ideas through interaction with other individuals or units. Boundaries can be physical, mental, or organizational." Wenger (2000) explains in his paper that at boundaries, competence and experience tend to diverge, but need to be converged to create communities. Such reconfigurations of the relation between competence and experience are an important aspect of learning. When competence and experience are too close, not much learning is likely to take place. In the opposite situation, when competence and experience are too disconnected, not much learning is likely to take place either. Learning at boundaries is likely to be maximized for individuals and communities when experience and competence are in close tension. (Wenger, 2000)

Achieving a generative tension between them requires (Wenger, 2000):

- Something to interact about, an intersection of interest
- Open engagement with real differences as well as common ground
- Commitment to suspend judgment to see the competence of a community in its terms
- Ways to translate between repertoire such that experience and competence interact

The requirements established by Wenger (2000) can be translated into the haptic language design. The complex social problem that the graduates will work on is the intersection of interest but this is already achieved. Open engagement and suspending judgment need to come from within the people themselves, but can be encouraged when guidance for the use of the haptic language is given. The guidance can help people to gain trust for open engagement by introducing some warm-up trust-building exercises. Furthermore, it can help to suspend judgment when it has a reflective character. Lastly, the haptic language itself can be a way to translate between repertoire.

In his article, Wenger (2000) distinguishes three types of bridges across boundaries: people that act as 'brokers' between communities, artifacts that serve as what Star and Griesemer (1989) call 'boundary objects', and a variety of forms of interactions among people from different communities of practice. In this graduation project a product for communication will be developed, i.e. an artifact that can be seen as a boundary object. The other types of bridges are not taken into account.

2.5 Boundary objects

Boundary objects can help to bridge across boundaries because they can help to transfer knowledge across these boundaries (Carlile, 2002, 2004). In transdisciplinary learning, boundaries exist because of different social worlds connected to different disciplines or knowledge perspectives. A boundary object provides a way for people to engage across disciplinary boundaries, offering a means of translation between disciplines. Ideally, these boundary objects or artifacts will help to make ideas understandable to people from other disciplines and sectors (McGregor, 2017).

Boundary objects can take many forms, but as Star and Griesemer (1989) write: "Boundary objects are objects which are both plastic enough to adapt to local needs and the constraints of the several parties employing them, yet robust enough to maintain a common identity across sites". These objects may be abstract or concrete. They have different meanings in different social worlds but their structure is common enough to more than one world to make them recognizable and, therefore, can act as a means of translation. The creation and management of boundary objects is a key process in developing and maintaining coherence across intersecting social worlds (Star & Griesemer, 1989).
Boundary objects are shared and shareable across different problem-solving contexts (Star, 1989). They support connections between different practices and can take multiple forms (Wenger, 2000) that enable different communities to interact despite differences (Wenger 2000; Craps, Dewulf, Mancero, Santos & Bouwen 2004; Cundill, Roux & Parker 2015):

- Artifacts, such as tools, documents, or models.
- Discourses, a critical boundary object is the existence of a common language that allows people to communicate and negotiate meanings across boundaries.
- Processes, shared processes, including explicit routines and procedures, allow people to coordinate their actions across boundaries.

To conclude, within this graduation project, the haptic language design that will be developed is seen as a boundary object that can help to cross the boundaries between the new graduate, the former graduate, and the management of UI. They all come in with their competencies and experiences from their discipline and their social worlds and have, therefore, their boundaries. To work together, these boundaries need to be crossed to create a shared understanding of the problem. This can only be done in a joint activity. The haptic language design will create an opportunity to have a joint discussion at the beginning of a graduation project.

2.6 Tacit Knowledge & Knowledge Creation

When the members of the CoP of UI come together to share their knowledge made possible with a boundary object and following the transdisciplinary learning cycle of Müller et al. (2005), they will also create new knowledge. Knowledge refers to thoughts and ideas that have already been experienced and have been stored in memory (Sanders & Stappers, 2018).

According to Sanders & Stappers (2018), there are four levels of knowledge: explicit, observable, tacit, and latent (see Figure 9). Explicit knowledge can be stated in words and is relatively easy to share with others. Observable knowledge refers to thoughts and ideas that can be obtained by watching how things happen or how people behave. Tacit knowledge refers to things we know, but which we are not able to verbally communicate to others. Latent knowledge refers to thoughts and ideas we have not experienced yet, but for which we can form an opinion based on past experiences. Latent knowledge will be knowable in the future.

Based on these four levels of knowledge and how they are described, in this thesis, the knowledge that UI wants to transfer between graduates is classified as tacit knowledge. This knowledge is about how the students did what they did in terms of their learnings, not their results. The results are already made explicit in a report that the graduates deliver at the end of their project. The experiential knowledge is hard to express right away and to state only in words, the graduates will need to take the time to think about it and use other means (like a boundary object) to share it with UI and the next generation graduates. Therefore, the experiential knowledge that needs to be shared can be seen as tacit knowledge.

Tacit knowledge was first described by Polanyi (1966) as the knowledge that cannot readily be expressed in words and is the opposite of explicit knowledge. In the literature, there is a discussion about if tacit knowledge can be made explicit and, therefore, transferred to other people. Polanyi and other thinkers like Wittgenstein (1953) suggest that tacit knowledge involves a background knowledge that includes physical skills and social know-how that result from immense histories of life experiences. In other words, it is too major to grasp and, therefore, not possible to make tacit knowledge fully explicit or suitable for knowledge sharing.

Polanyi (1967) and Buckingham Shum (1998) argued that tacit knowledge cannot be captured to be transferred to somebody else or that it can be converted to explicit knowledge for future consumption. In addition to this, Tsoukas (2003) argued that tacit knowledge cannot be 'captured', 'translated', or 'converted', but it can be displayed or manifested in what we do. Tacit knowledge comes about when our actions or communications are recursively emphasized. This can occur through a series of social interactions, personal reflection and insight, and through different forms of experiential learning.

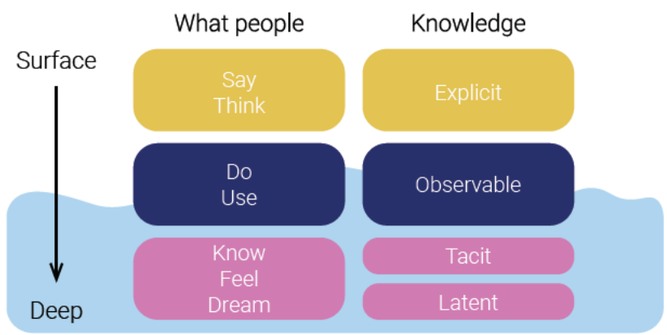


Figure 9. Different levels of knowledge (Sanders & Stappers, 2018)

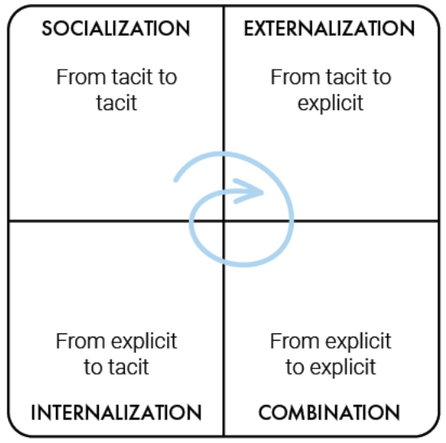


Figure 10. SECI Model of knowledge creation (Nonaka & Takeuchi, 1995)

On the other hand, others have argued that it is not impossible to capture or convert tacit knowledge, but that it is hard (Goguen 1997; Nonaka, Toyama & Konno 2000; Teece 1998). Nonaka and Takeuchi (1995) have even captured the transfer of knowledge from tacit to explicit in the SECI model (see Figure 10) representing the knowledge learning and its development cycle. The SECI model has four phases. The first phase is socialization, which is the transfer from tacit to tacit knowledge that happens face-to-face or through experiences, e.g. meetings or brainstorms. The second phase is externalization, which is the transfer from tacit to explicit knowledge. Hereby the tacit knowledge is made explicit such that it can be shared, e.g. concepts. The third phase is combination, which is combining different types of explicit knowledge, e.g. prototypes. This explicit knowledge can come from both inside as well as outside the organization. The fourth phase is internalization, which is the transfer from explicit to tacit knowledge. This phase is about continuous reflection and the ability to see connections and recognize them. In this phase, one can make sense between field, ideas, and concepts. It is when all four processes interact with one another—both in a personal and collaborative context, involving both tacit and explicit knowledge—that the "spiral" of knowledge creation becomes hyperactive (Tee & Karney, 2010). According to Nonaka and Konno (1998), these knowledge conversions must take place in a ba, a Japanese character that means shared context. The concept of shared context is related to the work of Lave and Wenger (1991), who argued that knowledge, particularly practical knowledge, is situated. Tacit knowledge resides in the context in which it exists.

When the fourth phase is established, knowledge can persevere within the organization. For UI this means that this fourth phase needs to be established, as well as the other phases of the SECI model. When the knowledge that is gained with a graduation project is preserved, a new graduate student can build upon that knowledge, following the SECI model. The model describes a spiral of knowledge creation and will, therefore, never stop. Knowledge is built continuously.

Sanders & Stappers (2018) state that generative design research tools and techniques will provide the means to see what is going on at the tacit and latent levels of what people know, and as such are a means to make tacit knowledge partly explicit. You want people to express their needs and values. One can best think about values by linking them to situations or occurrences, i.e., to stories. To help people express their tacit and latent knowledge, they propose to let a person first express the layer of facts. Then let the person indicate the high and low points which is the layer of valence. The last step is to ask why it was high or low, the layer of needs and values. Stepping up from stories about specific events to needs and values is a way to release tacit and latent knowledge.

To conclude, it is hard to make tacit knowledge explicit and to transfer tacit knowledge to others. Different scholars have argued that it can be partly done if one makes use of other means to express thoughts and feelings than mere words. But transferring all tacit knowledge from one person to another person is simply not possible. In this master thesis research will be done on other means that can help people to express their tacit knowledge.

2.7 Operationalization table

Theory	Concept	Sub-concepts	Meaning
Social Learning Systems (SLS)	Social definition of learning	Social competence	What it takes to act and be recognized as a competent member of a community.
		Personal experience	The experience people have in their own world in the context of a given community and beyond.
	Three Modes of belonging to participate in an SLS	Engagement	Doing things together, joint activities.
		Alignment	Making sure activities align with other processes.
		Imagination	People construct an image of the world to help them understand how they belong to that world and reflect on their situation.
Communities of Practice (CoP)	Three elements that create a CoP	Domain of interest	Interest in, commitment to and expertise in the domain of interest distinguish members from other people.
		The community	Members engage in joint activities and discussions, help each other and share information.
		The practice	Members develop a shared repertoire of resources to use within the community.
Transdisciplinary Learning	Three-step learning cycle	The normative step	People have their purpose, concepts, knowledge, and interpretations of the world.
		The creative step	People pose actions informed by their internal perspectives
		The descriptive step	People observe and describe the actions and consequences of the creative step that lead to different viewpoints that inspire the creation of new knowledge, ideas, and concepts.
	Three group mindsets	Knowledge boundary objects	Knowledge exchange requires members to come together and to cross boundaries with boundary objects because they all come from different disciplines and different social worlds.
		Communities	Transdisciplinary learners need to commit to the collective creation, expansion, and building of knowledge through knowledge creation communities.
		Metacognitive skills	Transdisciplinary learners must be able to think about and monitor their thinking.
	Seven individual habits of the mind	Perceiving	Call to mind what is observed with the five senses.
		Patterning	Recognizing and forming patterns.
		Abstracting	Capturing the essence by eliminating features and concentrate on one feature.
		Embodied Thinking	Bodily thinking exemplified by sensations and feelings in the body.
		Modelling	Creating a representation of something in real or theoretical terms.
		Deep play	Playing to open new ways of thinking.
		Synthesizing	Tying together the previous habits, different ways-of-knowing into a synthesized whole.

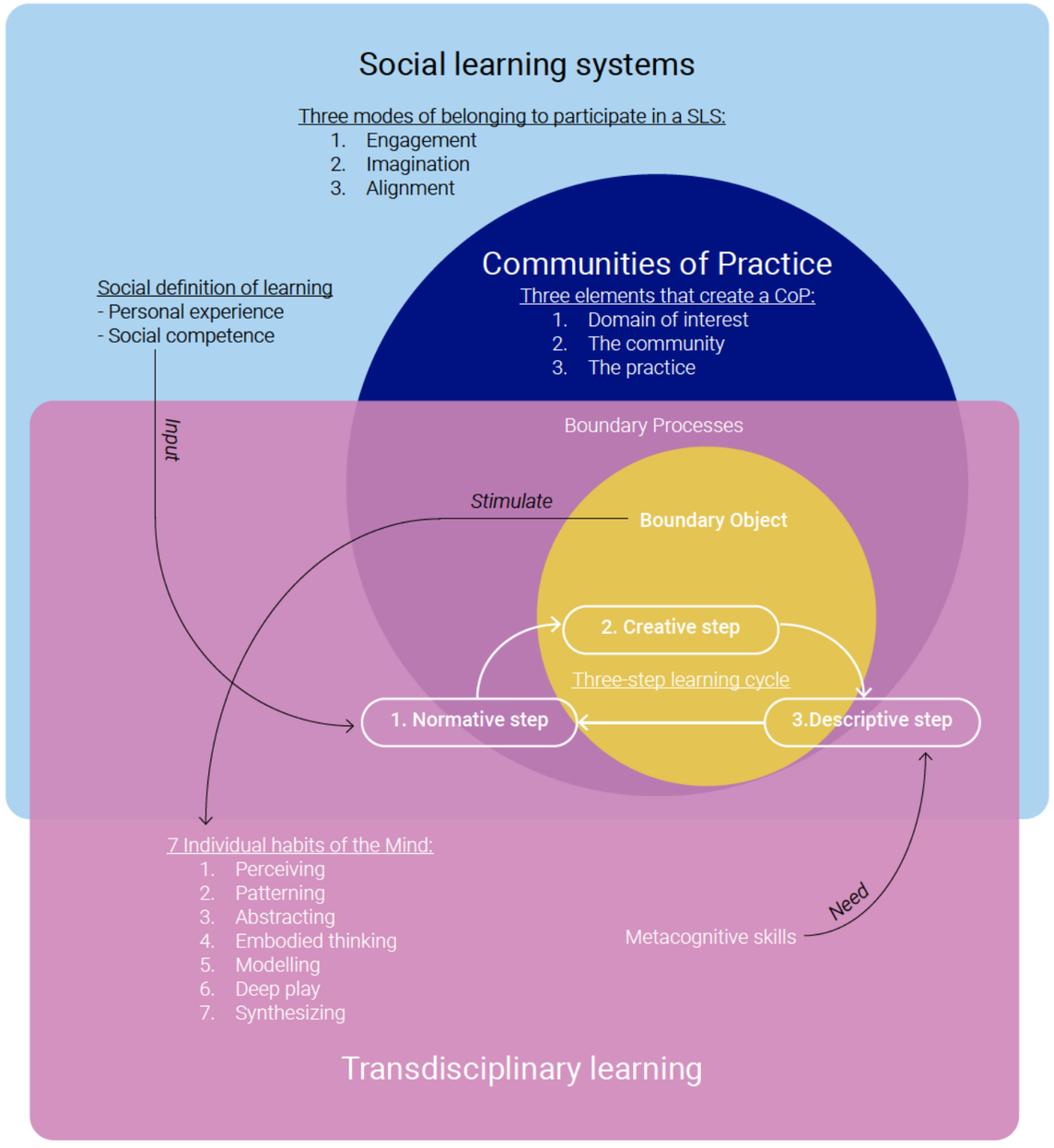


Figure 11. Overview of the theoretical concepts and how they fit together

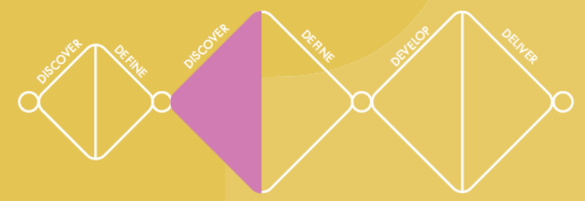
CHAPTER 2
KEY TAKEAWAYS

Bringing theory and problem together, to close the gap between consecutive graduation projects within UI, a boundary object needs to be created. This boundary object can help to bridge the different social worlds of the graduates and therefore translate between their different disciplines. Using the boundary object will create a shared activity and the first tool for a shared repertoire that are needed to create a CoP.

The interactions that take place between disciplines with help of the boundary object foster transdisciplinary learning and the creation of new knowledge. The knowledge that is shared in the interactions should be experiential knowledge which is often tacit knowledge. Tacit knowledge Is hard to express words. It can be done by guiding someone from the layer of facts to the layer of needs and values or by make tools from the context mapping method.

However, expressing tacit knowledge needs guidance and cannot be done with only spoken words. For individuals, the 7 habits of the mind explain that for transdisciplinary learning it is also important to make use of all the 5 senses of the human body. Therefore, it is interesting to see how the senses can help to let someone express their tacit knowledge. From touch, it is known that it can deepen communication. Therefore, the focus of this master thesis will be on creating a haptic boundary object that can help to transfer experiential knowledge between graduates of UI. In the next chapter, haptics is explored to get an idea of how touch could be integrated into a boundary object for knowledge sharing.

HAPTICS



CHAPTER 3

‘THERE IS MORE TO TOUCH THAN MEETS THE EYE.’

Lederman & Klatzky (1987)

From chapter 2, the theoretical background, it became clear that for UI to establish a learning community, they need to provide interactions between students preferably with a type of boundary object to get knowledge transferred. Because it can be difficult to articulate and therefore transfer tacit knowledge, a way to support students in this process needs to be developed. The idea of this master thesis is to research if touch, referred to as haptics, can be integrated into a type of boundary object to expand the vocabulary for expressing tacit knowledge. With the use of haptics as the mean of communication, an extra option to express oneself is provided, and sharing personal experiential tacit knowledge becomes easier.

To get an idea if haptics is useful in transferring experiential tacit knowledge, first an understanding of haptics in general needs to be obtained. Therefore, this chapter explores how the sense of touch is used and how haptics is applied in physical designs. The chapter first outlines the sensors people use for touch and the procedures that are performed when touching an object. Then the relationship between touch and the other senses is explored and lastly, haptic design examples are discussed.

Introduction

The word haptic originates from the Greek word ‘haptikos’, which means ‘able to touch or grasp’. Touch is one of the five senses of the human body, alongside smell, sight, taste, and hearing. Like the other senses, touch informs us about our surroundings, prevents our body from danger, contributes to the exploration of an object, and has an emotional component that can give us a feeling of safety and pleasure (Ackerman, 1990). The sense of touch depends on contact, which makes touch an ‘active’ sense. We have to physically interact with an object to activate the sense of touch. The sense of touch is unique in that its sensors are spread over the whole body.

3.1 Cutaneous and Kinesthetic sensors

The sense of touch uses two different types of sensors, i.e., cutaneous or tactile sensors, and kinesthetic or proprioceptive sensors. The cutaneous sensors are embedded in the skin and together with the kinesthetic sensors in the muscles, tendons, and joints, they form the haptic system. This haptic system uses the sensory information derived from these sensors to recognize objects. This recognition of objects through touch is called haptic perception. Haptic perception is part of the discriminative touch system that provides facts about objects and our surroundings (Linden, 2016).

3.1.1 Cutaneous sensors

The cutaneous or tactile sensors are based on the whole skin of the whole human body, but not every part of the body is equally sensitive to touch. Our fingertips are the most sensitive locations on our body, followed by our lips. In Figure 12, a representation of the sensitivity of the skin of our whole body can be seen.

Figure 12. 3D sensory homunculus model

The fingertips being the most sensitive locations on our body has to do with the four different types of mechanoreceptors that are active in the hands. Each of these receptors is specialized to retrieve certain features of an object. These four different receptors or sensors are:

1. Meissner’s corpuscle that senses skin motion
2. Merkel cell complex that senses fine tactile discriminations like form and texture
3. Pacinian corpuscle that sense vibrations transmitted by body contact when grasping an object
4. Ruffini ending that senses skin stretch

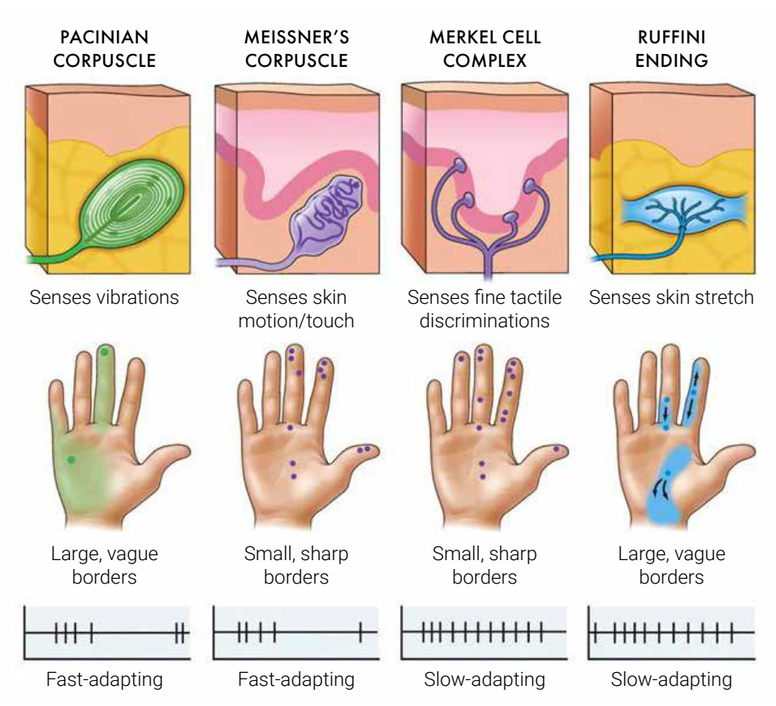


Figure 13. Overview of mechanoreceptors in the hands based on Properties of skin receptors related to touch in biological psychology 7e, Figure 8.

Of these sensors, Meissner's corpuscle and the Merkel cell complex have small and sharp borders while the Pacinian corpuscle and Ruffini ending have large and vague borders. Meissner's corpuscles and Pacinian corpuscles are fast-adapting sensors, meaning that they respond to rapid mechanical changes such as those produced by vibration. The Merkel cell complex and Ruffini corpuscles are slow-adapting sensors that respond to slowly changing or static stimuli (Kahol & Panchanathan, 2008). In Figure 13 an overview of the four sensors can be found.

To make it more concrete what the function of each of these sensors is in daily life, an example of finding a quarter in a pants pocket and placing it in the slot of a parking meter will be given retrieved from Linden (2016). The Merkel cell complex allows us to distinguish individual surface features with our fingertips and helps to identify the rough-textured ridges on the edge of the quarter. The Meissner's corpuscle helps to identify the minimal amount of force needed to hold the quarter securely and, therefore, fine-tunes the grip strength. The Pacinian corpuscle allows feeling the sensations that are transmitted when the quarter touches the internal walls of the slot and makes people use this feedback subconsciously to alter the trajectory of the arm, hand, and fingers to insert the quarter smoothly. How Ruffini ending receptors, which are involved in sensing horizontal skin stretching, contribute to this process is poorly understood.

Besides the four mechanoreceptors, there are also sensors in the skin that react to nonmechanical stimuli. These sensors are involved in sensing pain, itches, certain chemicals, inflammation, and temperature (Linden, 2016). The sensors that respond to increases or decreases in skin temperature, and mediate the human experiences of warmth and cold are called thermoreceptors (Lederman & Klatzky, 2009).

Overall, the cutaneous sensors are actively involved in the haptic perception of surface properties of objects such as texture, material, temperature, and surface disturbances (Hatwell, Streri & Gentaz, 2003). But they also include pressure and pain.

3.1.2 Kinesthetic sensors

The kinesthetic or proprioceptive sensors are based on muscles, tendons, and joints. These sensors process sensations of movement from the body and limbs. There are two different sensors for the muscles and tendons. The muscle spindle is the sensor embedded in the muscles and the Golgi tendon organs (GTO) are embedded in the tendons (Kandel, Schwartz & Jessell., 2000). In haptics, kinesthetic sensing is used to measure the gross shape and feel of objects (Hatwell et al., 2003).

3.2 Exploratory Procedures

The cutaneous and kinesthetic sensors help us to identify objects. According to Lederman & Klatzky (1987), there are two distinct phases for object perception. The first phase consists of general procedures that mobilize the whole hand and gather vague information on several properties. The second phase consists of specific procedures to gain more detailed information (Lederman & Klatzky, 1987). People tend to get an overall picture of an object and then perceive specific properties if they want to or if it is requested. This suggests that haptic perception need not always be complete. Often people will analyze objects based on a "level of interest" (Kahol & Panchanathan, 2008).

The different properties of objects that can be perceived haptically are texture, hardness, shape (Lederman & Klatzky, 1987), temperature, weight, volume, part motion, and specific functions. These properties are also referred to as haptic dimensions. According to Lederman & Klatzky (1987), all these different properties or haptic dimensions have their exploratory procedure, which can be seen in Figure 14. Exploratory procedures are the hand movements that people use to retain information about the haptic dimensions. Because all people use the same hand movements to retain information of a specific dimension, they can be generalized as exploratory procedures. The exploratory procedures are often executed unconsciously and alternate when objects are examined.

Some of the exploratory procedures are very specialized while others are more general. Static contact, for example, can also give clues about shape, size, texture, and hardness just as enclosure. And contour following can also give a vague idea about texture and hardness. Individuals are not able to perceive properties or features haptically if they do not execute the corresponding manual exploratory movement (Lederman & Klatzky, 1987). Also, the exploratory procedures are observed to be not motorically compatible and, therefore, cannot be executed at the same time.

Besides the dimensions that Lederman & Klatzky (1987) describe, one can also feel stickiness, wetness, viscosity, and inertia.

3.3 The five senses

The level of interest for evaluating an object further is not only triggered by the first touch and exploratory procedures but starts with the first sight of the object. Sight can motivate further haptic exploration (Kahol & Panchanathan, 2008). In real environments, sight is accompanied by additional sensations like smell and sound. Before people touch an object, their eyes have already made a rough estimation of it and, if applicable, their nose has smelled it and their ears have heard the sound it makes. With this information of the object, people decide if they want to touch it to gain a deeper understanding of it or not. The five senses do not act independently of one another.

By sight, people retrieve information about the shape, size, texture, and color of objects, by hearing people retrieve vibrations, echoes, or noises that the objects produce. With touch people can also retrieve information about the shape, size, and texture of objects, but also temperature and weight can be retrieved. When an object is being touched, the information retrieved from this touching is combined with the inputs from vision, hearing, and proprioception (a sense of where our bodies are located in space that comes from nerve endings in our muscles and joints)

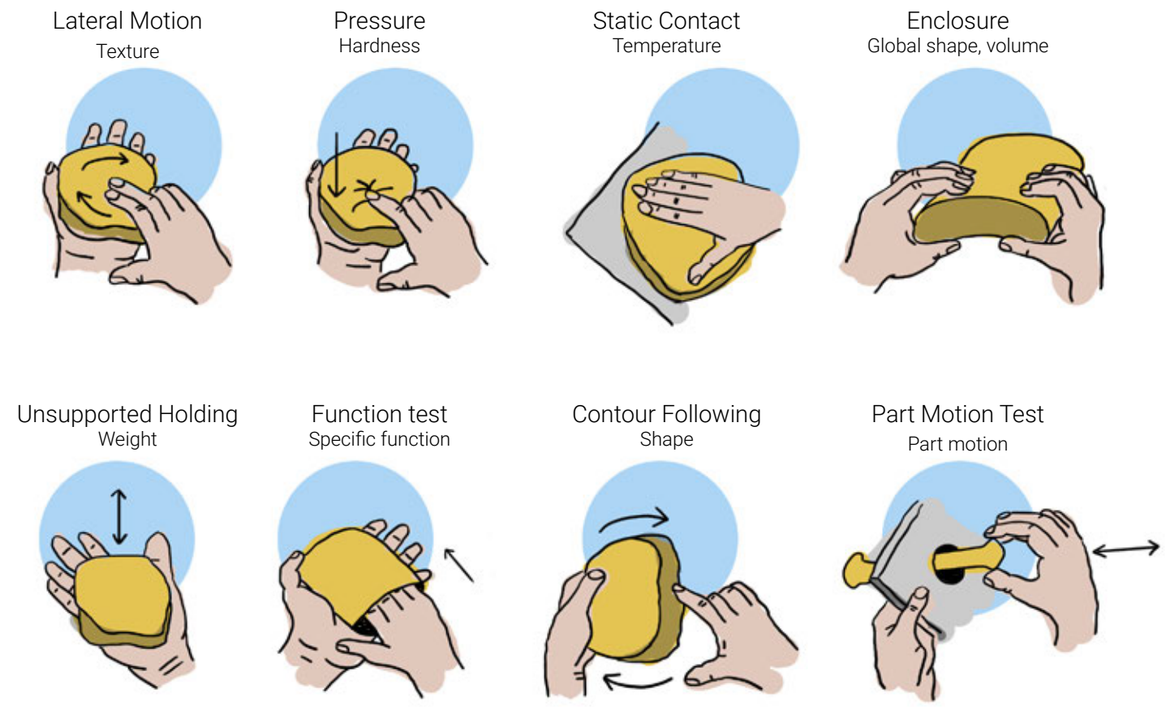


Figure 14. Exploratory procedures (retrieved from Lederman & Klatzky, 1987)

to give a total picture of the object (Linden, 2016). Our brains process the information retrieved from all senses into a multisensory perception. Based on all the observations of the senses, people gain insight into the world and how it works.

One of the most interesting findings that has emerged from much of the research on multisensory perception is that vision tends to dominate over the other senses under the majority of laboratory conditions. As a consequence, multisensory perception is often influenced most strongly by what we see (e.g., see Bertelson and de Gelder 2004; Rock and Harris 1967; Welch and Warren 1980, 1986, for reviews)

Haptic sensations are not only accompanied by the other senses but also influenced by them. The classic size-weight illusion of Charpentier (1891) showed that when two weights have the same mass but different sizes, the smaller one is perceived to be heavier, irrespective of whether the size is seen or felt (Hayward, 2016); similarly, sound can affect how a texture feels (Hayward, 2016).

3.3.1 Difference between sight and touch

Although the senses sight and touch can retrieve overlapping properties of objects, there is also a fundamental difference between them. With sight, people can retrieve detailed information and overview at the same time. This is called “simultaneous sensation” (Withagen, 2010). With touch, it is not possible to encompass large objects at once. A large object needs to be explored little by little meaning that the information retrieved comes in small parts. This is called “sequential observation” (Withagen, 2010). To get a total impression of an object, the small parts of information need to be compiled into one overall image. This implies that touch relies more on memory than sight. If concentration slips during exploration of an object, information gets lost and the overall object image is distorted. With sight, one works from the whole to the smaller parts, with touch one works from the smaller parts to the whole (Withagen, 2010).

With touch, people can grasp an object with both hands to simultaneously “view” the front and back in one go. This is not possible with sight since the object needs to be turned around to view the back. This characteristic of touch is called three-dimensional perception (Withagen, 2010). With small objects, touch provides more information about the object on all sides compared to sight.

Lastly, sight and touch differ in the way in which sense is preferred for certain dimensions. As Kahol & Panchanathan (2008) stated, tactile texture perception is as efficient as visual texture perception but in cases of extremely fine texture, the haptic modality surpasses the visual modality. Touch is specialized to perceive textures. Cooke, Jäkel, Wallraven & Bülthoff (2007) found that with sight, participants found shape more important than texture, but in touch, they relied on both shape and texture.

3.4 Examples of haptic design

Haptic Cube

This design makes the Rubik's cube accessible for visually impaired people. It has six different textures on the surfaces to distinguish between the six sides.

Figure 15. Haptic Cube

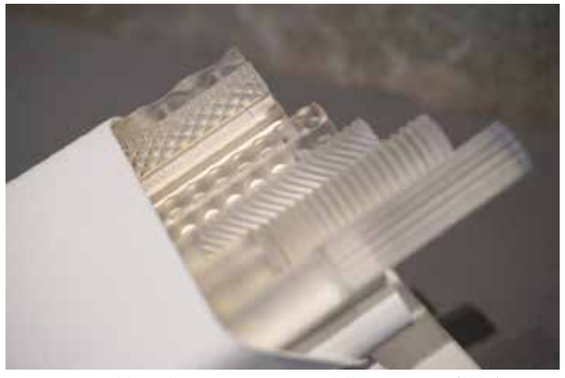


Figure 16. Lip Service by Kyoko Kita & Sako Kantarol (2017)

Lip Service

It seeks to update the traditional luxury item of tobacco from the angel of haptic stimulation by the lips. The tops contain 10 different materials with a different feel, so the lips can experience a range of

Hello Haptic flash cards

These flash cards are created to teach blind children the textures they may encounter and what they are. It also teaches blind children smell.

Figure 17. Haptic Geta by Shuhei Hasado, Takeo Paper Show 2004

Haptic Geta

Get are traditional Japanese sandals. These are made of wood, moss and other textures. With this design people use the sensory nerves on the bottom of their feet.

Figure 18. Flash cards about the world by Hello Haptic

Figure 19.Conversation pieces by Nicolette Bodewes (2016)

Conversation pieces

This haptic set is part of Tools for Therapy, a toolkit that helps people in therapy to express their thoughts. The haptic elements can represent situations, people, feelings and thoughts and are based on the Jungian archetypes by Carl Jung.

Ridgeline User Interface

A new switch interface focused on the sense of touch. This switch uses the motion of 'a finger sliding across the ridge of perception' to generate swithc and tactile feedback.

Figure 20.Tactiel Profiel by Visio

Tactiel Profiel

This toolbox is used as an observation tool that maps tactile functioning in children with a severe visual impairment. It is based on letting participants experience, hear and appoint what they feel. It is developed and used by the institute for the blind Visio.

Tactux

This is the Tactile User Experience Assessment Board, a tool to asses user experience through tactile properties. It is focused on tactile perception of surfaces and experiences associated with it.

Figure 21. Ridgeline User Interface by Shigeya Yasui (2016)

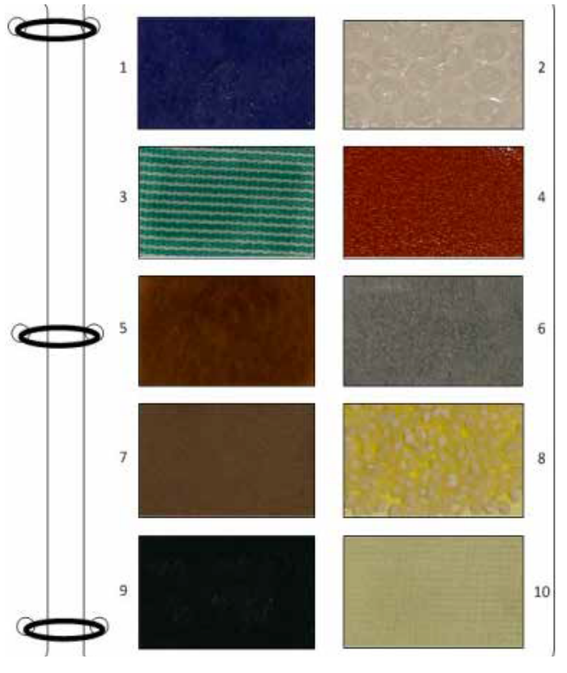


Figure 22. Tactux by G. Regal, P. Wokerstorfer, M. Bush, M. Tscheligi and C. Hochleitner (2014)

CHAPTER 3

KEY TAKEAWAYS

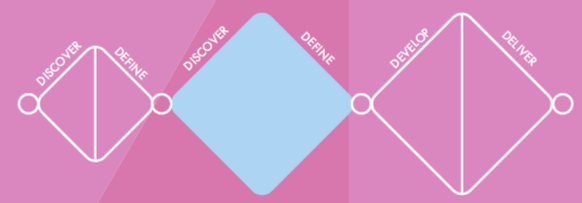
From this chapter, it can be retrieved that the sense of touch can be experienced throughout the whole body, but our hands are the most sensitive to touch. Our hands contain four different types of sensors to detect different touch experiences. The dimensions that can be retrieved from touch are texture, hardness, temperature, shape, volume, and weight. These dimensions all have their exploratory procedure, a specific hand movement, to explore them. Also, part motion and specific functions can be explored with exploratory procedures.

The dimensions shape, volume, and texture can also be perceived by the sense of sight. The dimensions temperature and weight are dimensions related to touch only. One can therefore not neglect the sense of sight when designing for haptics. All the five senses of the human body influence each other, so the haptic design is multisensory.

Design takeaways

- The haptic design does not have to be for hands only, but can also make use of different parts of the body like feet or lips
- The haptic design will be influenced by other senses and is therefore multisensory
- The haptic design uses different textures and materials to create different touch experiences
- The haptic design helps people to express what they feel to get more out of a touch experience
- The haptic design can also be used to control something or adjust something

EXPLORING HAPTICS



CHAPTER 4

4.1 Test 1: Influence of feeling materials on transferring information
4.2 Test 2: Use of textures in communication
4.3 A creative session with peers

This chapter builds upon the theory of haptics and the haptic designs that are explored with exploratory research. After chapter 1 an understanding of the company and the problem is established, while a deeper understanding of the context is gained with the theoretical background in chapter 2. In chapter 3 an understanding of what haptics means, how it works, and how it is applied in design has been discovered. The next step is to research how haptics can be used in communication because it is an essential part of answering the research question.

Therefore, this chapter explores how haptics can be used in communication by two types of experiments and creative brainstorming sessions with peers. The first experiment gives a first impression of how feeling textures can influence the communication of the participants. The second experiment gives a better understanding of how the haptic dimension texture, which is seen as the most versatile haptic dimension, can influence the communication between participants.

After these two experiments, two brainstorming sessions with peers are held to get an idea of the possible design directions that can be explored for developing a haptic language. For each part, the goal, method, key findings, and conclusion are described. The chapter ends with a conclusion of the most important findings to integrate into a prototype design.

4.1 Test 1: Influence of feeling materials on transferring information

Goal

There is little known about how consciously feeling can influence the way how people communicate. To get a better understanding of how consciously feeling of different materials can influence the way people transfer information, a test has been designed to research if there is a difference in transferring information after different materials are explored by only touch, only sight, or a combination of touch and sight.

Method

The test consisted of two different parts. In the first part participants evaluated materials and the second part participants read a case description and transferred that information to another person. For this test, three participants were tested with all different conditions. One of the participants was only allowed to look at the materials, one of the participants was only allowed to feel the materials and was therefore blindfolded and one of the participants was allowed to look and feel the materials. Each participant received the same materials and the same type of questions for each material. All participants also received the same case description of the problem. A detailed set-up for this test can be found in Appendix B.

Hypotheses

1. Feeling materials creates different associations than just seeing materials.
2. Seeing and feeling materials provides a more extensive description of the material.
3. Seeing and feeling materials creates more associations compared to only seeing or feeling.
4. Feeling materials makes it easier to have a feeling with a material.
5. Only seeing or only feeling creates different feelings and emotions with the material.
6. Seeing and feeling produces a combination of the different feelings and emotions mentioned by only seeing or only feeling of materials.
7. Participants who have felt the materials use the materials as an example to indicate what they feel when reading the case, it feels just like material x, because ...
8. Feeling materials allows for the use of more adjectives.

Key findings

1. Materials are too recognizable

Because the materials could be recognized easily by both sight and touch it was hard for participants to reach a deeper level of exploring the materials. The exploration stayed on a factual level, e.g., “this feels like sandpaper”. The easily recognizable materials do not enable the participants to associate freely.

2. Materials did not evoke feelings

The participants found it hard to indicate feelings and emotions with the materials. Participants struggled with answering the question “What do you feel with the material”. They do not have feelings with a certain material, but they can have feelings and emotions with memories they have with the materials, e.g., sandpaper made the participant think of remodeling a house, and on the question “What do you feel with the material” she answered, “an entrepreneurial feeling” which was associated with the remodeling of a house.

3. Consciously seeing and feeling materials has no prime effect

The first step of consciously feeling and seeing materials did not affect the second step whereby information was transferred. There was no indication that what information the participants conveyed and how they conveyed the information would be different with a different condition in the first step. Feeling or seeing materials consciously will not influence the transfer of information when it is done in separate steps.

4. The order of asking questions can make a difference

The first question asked during the test is “Can you describe what you feel or see” which is very factual. This can make it harder for people to think about associations in the next question apart from the facts they have mentioned earlier. In the next test, it would be better to first ask for associations and feelings, before asking the facts or to not ask for facts about the materials at all.

Conclusion

From the three participants, there was no indication found that there would be a difference in the number of associations with the materials or the size of the description that is given. Feelings and emotions were hard for participants to address and none of the materials and how they feel is mentioned during the explanation of the problem in step 2. The two parts of the test seem not integrated. From this test set-up, there is no clear indication of how feeling or seeing the materials can change the transfer of information between people and if there is a difference between feeling and seeing. Because after three participants it became clear the test design was not suitable to deliver answers to the hypotheses, a new test design was created that can be found in the next paragraph.

For this test set-up, haptics is integrated with the transfer of information between persons and not separated in a first step, because there is no indication that there is a priming effect when people first see and touch materials before they transfer information. Furthermore, the next test set-up is in pairs instead of individually. In the context of the problem, UI wants to close the knowledge gap between students, so a transfer of information from one student to the other has to take place. Testing in pairs will help to get a better understanding of how haptics can work during transferring information from one person to another.

4.2 Test 2: Use of textures in communication

Goal

There is little known about the influences of haptic dimensions on communication. To get a better understanding of how dimensions of haptics can influence communication, a test has been designed to research if and how textures can influence the communication between people. Texture is the most versatile dimension. Other pure haptic dimensions like weight or temperature can differ between heavy and light or warm and cold. With textures, one can feel the hardness, roughness, softness, stickiness, etc. Texture is therefore indicated as the most interesting dimension to use in a haptic language design.

Method

For this test, a wooden block set is used for half of the participants and transformed with textures for the other half of the participants, see Figure 23. The participants were asked to analyze the problems around the energy transition in Rotterdam South by building the problem with the blocks. They received a case description with information that they could use as input. Before the analysis of the problem, the participants were asked to perform two warm-up exercises to get acquainted with the use of the blocks. After the analysis, the participants were asked to fill in an evaluation form. The detailed set-up and evaluation forms can be seen in Appendix C.

Hypotheses

1. Groups of people that have textures at their disposal will first explore the blocks by touching and feeling them, while the group with no textures has no interest in touching and feeling the blocks before working with them. So, the textures invite people to explore the blocks.
2. The groups that have textures at their disposal will use these textures to talk about the case, they will explain their thoughts by using the feeling of the texture, e.g., a smooth texture can be used to explain that there is smooth communication between two involved stakeholders, while a rough texture can be used to explain a communication that falters.
3. The groups that have textures at their disposal find it easier to use the building blocks because they have more possibilities in usage. They can not only use the height and length, combine blocks, but they can also use the different textures to indicate different types of relations.
4. The groups that have textures at their disposal will pass blocks around to let other people feel what they mean and to discuss if the other agrees with this texture.
5. The groups that have textures at their disposal will take longer to make decisions about which blocks to use and how to build the complex problem.
6. The groups that have textures at their disposal will have more interaction during the discussions, meaning they will talk more about how to use the blocks and will more often pass blocks around.
7. The groups that have textures at their disposal will attach more and different values to both the blocks in general as well as the textures.

Key findings

1. Visual dimensions are dominant

No matter which block set was used during the test, in both cases, the dimensions shape, and size were used the most to indicate values and group the objects during building the problem. Shape and size can both be retrieved by sight and touch, but the preferred and first way to indicate them is with sight. Textures can also be retrieved by vision and touch, but the preferred way to explore texture is with touch. The results of the test indicate that people prefer to use the dimensions that can be retrieved the most easily by sight.

2. Small differences in textures are not noticed

The little differences between the textures that are used during building were not recognized. For example, all things made from fabric were labeled fluffy and soft, while all things with wallpaper were used to indicate something with “3d-texture”.

3. Use of the elements needs to be stimulated & guided

During the test, it is noticed that after a while when the discussion is heated, people tend to forget the blocks and return to only talking. It was also noted that it is hard for participants to start using the blocks because it does not feel natural. The results of the test indicate that usage in general and continued usage need stimulation and guidance.

4. Dimensions are used for distinctions and clustering

No matter which block set was used during the test, the differences between the blocks were used to cluster them. The dimensions shape, size, and texture were all used for clustering, so the dimension did not seem to matter. For example, all the fluffy blocks or all the small blocks were grouped into “residents of Rotterdam South”.

Figure 23. Block sets used in test 2

5. 3D objects are more flexible

In the evaluation after the test, it was noted that the advantage of using 3D objects to build the problem is flexibility. 3D objects are easier to rearrange compared to sketching whereby you mostly have to start over with a new sketch when you want to change something.

6. Elements must be balanced

In the block set used during the test all blocks were unique, every combination of shape, size, and texture was different and this was indicated as disturbing. Therefore, in the final concept, the textures, shapes, and sizes must be more balanced, meaning more of the same textures, shapes, and sizes. Also, more blocks that are completely identical.

7. Different ways of usage

From the observations and the evaluation forms after the test it is indicated that the building blocks can help the participant in 4 different manners:

1. It can help to visualize the problem
2. It can help to create an overview
3. It can help to summarize information
4. It can help to get an idea of how someone else processes information and thinks

Conclusion

From the observations and evaluations, it became clear that the blocks with textures do not necessarily invite further exploration at the beginning of the test. It can be the case that participants felt they were not allowed because of the test set-up. The different properties of the textures like smooth or rough are hardly mentioned or used and blocks with textures are not passed around between participants. More possibilities in usage when the blocks contain textures is not indicated as easier, both groups seemed to have the same struggles and it is not found that with textures the decision process of which blocks to use took longer. Also, no indication was found that textures led to more interactions between participants or that different values are used for blocks with textures compared to the wooden blocks. From these conclusions, it cannot be said if and how textures influenced the communication between the participants. However, it is indicated that vision is important to take into account when designing for haptics and that the use of abstract elements probably needs stimulation and guidance. A haptic language design will be new for the participants and can therefore be scary to use for the first time.

Figure 24. Snapshot of participants building the problem during test 2

In this test, all groups of participants received the same information. There was no question of transferring one’s knowledge. In the context of UI, it will be the case that a graduate will transfer his knowledge to the next student. Therefore, in the next test set-up, it is important to zoom in on this specific context scenario, to see if haptics makes sense to use in that context.

4.3 A creative session with peers

After the tests have indicated what could be important to integrate into the haptic language design, a creative session is organized with peers to get a broad idea of how haptics could be integrated into a communication tool. Before the session, a brainstorming session with other graduates is held to research if the problem statement gave the right sort of ideas and was suitable for the creative session.

4.3.1 Pilot brainstorming session with peers

Goal

The goal of this brainstorming session was to check if the problem statement was suitable for the creative session. Furthermore, the brainstorming session could deliver useful ideas to explore further and be used as a source of inspiration.

Method

The session was organized by myself with methods retrieved from the book 'Road Map for Creative Problem Solving Techniques' by Heijne & van der Meer (2019). In the session 3 graduate students from Industrial Design Engineering participated and I functioned as the facilitator of the session. The session lasted 1,5 hours. The problem statement for the session was: "*How can we adopt the sense of touch in our communication with others*".

Key findings

All ideas with clusters can be found in Appendix D.

- The phrases '*sense of touch*' and '*communication with others*' in the problem statement are very broad and vague and were hard for the participants to work with.
- The phrase '*sense of touch*' makes participants think of personal touch or touching each other, therefore a lot of ideas included touching other persons, e.g., touching the upper arms of someone else means you are feeling good or you agree. For the creative session, the focus should lay more on touching physical 3D objects.
- Many ideas were focused on showing your feelings or emotions, e.g., 'put your feelings into memory foam and to send it to another person'.
- Every participant had at least one idea in which another sense was consciously included or excluded.

An overview of all the results of the session can be found in Appendix D.

Conclusion

During the session, it became clear that the problem statement was too vague and a lot of ideas were based on touching other persons. From the context of UI, it is retrieved that it is about transferring experiential knowledge between students. This means the haptic language is not about showing your feelings, but more about the process that the students went through and how they tackled problems. Furthermore, the haptic language will be a 3D object that can physically be touched and used. So, for the creative session, these two things need to be taken into account when writing the problem statement.

4.3.2 Creative session with external facilitator and peers

Goal

The goal of the creative session was to get an understanding of the possible design directions for the haptic language design and to get inspired by others.

Method

This session was organized with an external facilitator, Ishit Patel, with methods retrieved from the book 'Road Map for Creative Problem Solving Techniques' by Heijne & van der Meer (2019). In the session, 5 other people participated, 3 students from Industrial Design Engineering, 1 graduate student from UI, and 1 external creative person. I also participated in the session as the problem owner. The session lasted 2 hours and was hosted online using Zoom and Miro. The problem statement for the session was: '*How can the sense of touching an object help us better share our experiences*'.

Key findings

One of the most interesting findings during the creative session was that there are a couple of design choices that need to be made to get a better idea of what the haptic language design should look like for UI:

- Is the haptic language design based on predetermined objects that can be used during a session, e.g., the conversation pieces by Nicolette Bodewes (see chapter 3.4) or is it an object that students need to build themselves during their graduation project?
- Is the haptic language design something that you build during your graduation project or is it something you use after your graduation project is (almost) finished as a reflection tool for example?
- Is the haptic language design used for an individual experience or a shared experience with peers? And if it is a shared experience, will people touch it only individually, or do they need to touch it at the same time?
- If the haptic language design consists of different elements, will these elements be predetermined in meaning, e.g., cold is negative and hot is positive, or will the elements be self-interpretable?

Other findings from the session:

- Do not only think about objects that are small enough to be used on the table but also think about bigger objects you can put on the floor or installations you can walkthrough.
- It does not necessarily need to be used with your hands, you have sensors over your whole body in your skin that can register touch, so you can also think about using your feet or other body parts like lips that are very sensitive to touch.
- Before you can share your experiences, you need to be conscious of them. Maybe first an individual reflection moment is needed before any transfer of this experience can happen. A preparation exercise to ease participants into the topic is also often used in the context mapping method.
- Do not forget to include things that feel unpleasant.
- Think about how you can let someone else relive the experiences. When the student has built it during his graduation it becomes static and it is almost impossible for the other student to relive it.

An overview of all the results of the session can be found in Appendix E.

Conclusion

After this session, it became clear that there are a couple of design choices that need to be made to get insight into how the haptic language design for UI should look like. Furthermore, it is important to think about how students will be able to share their experiences. For example, students can prepare a preparation exercise to become aware of their experiences. Also, when students built something during graduation, it will become static and therefore harder to share experiences, because there is not much room for the other student to relive it.

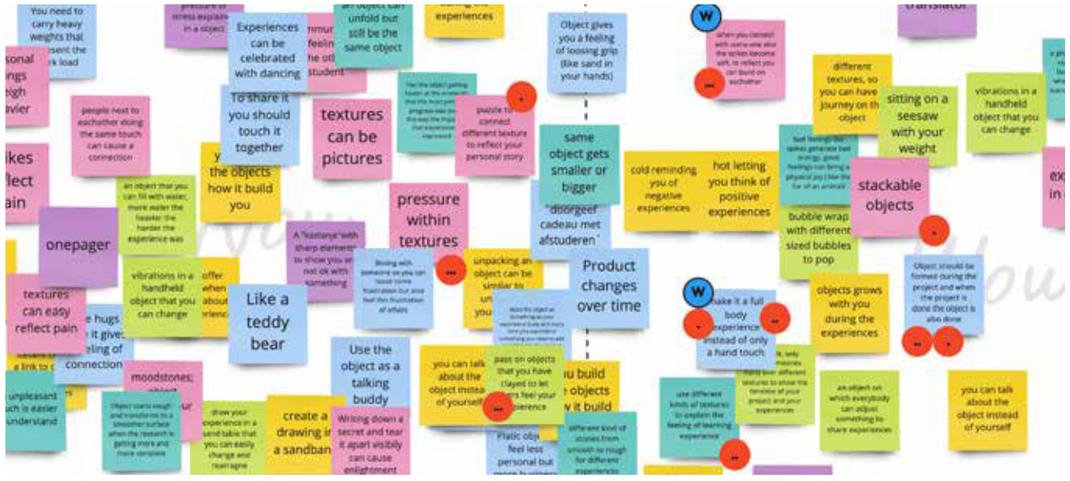


Figure 25. A screenshot of the C-box from the creative session in Miro

CHAPTER 4

KEY TAKEAWAYS

From this chapter, key findings are found for haptic design in communication and haptic design in the context of UI. These key findings need to be taken into account when designing the haptic language design for UI.

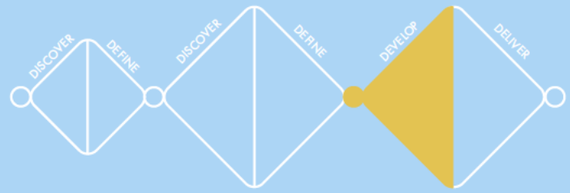
Haptic design in communication:

1. Materials should not be too recognizable when applied to a haptic design for communication to interpret the materials more broadly and therefore more abstract.
2. Visual properties are dominant and can distract from haptic properties.
3. Consciously feeling of materials before transferring knowledge does not have any effect and it makes more sense to integrate haptics in the transfer of knowledge, so use haptics as a means to transfer knowledge.
4. Haptic usage is counterintuitive and needs stimulation and guidance.

Haptic design in the context of UI:

1. Think about how the former graduates can be prepared to share their experiences because you need to be aware of your experiences before you can share them.
2. Do not make the haptic language design static, meaning there is room for the new graduate to relive the experiences of the former graduate.

PROTOTYPE TEST



CHAPTER 5

This chapter explains the synthesis of all the findings gathered from the theory and exploratory research into a prototype design. With this prototype, further research was done into how haptics can contribute to the transfer of knowledge in the context of UI. The prototype is partially based on VormTaal by Anne Kamp (2018) and the findings gathered so far. The prototype was used as a research tool that was tested in the context of UI. The findings from the prototype test were used to establish haptic design principles that need to be integrated into the final design.

The chapter first describes the design of the prototype with an explanation of the decisions made, followed by the method that was applied to test the prototype, the hypotheses, and the findings gathered from analyzing the data. The chapter finishes with design takeaways for the final concept design and a conclusion.

5.1 Design

The prototype that has been created is a toolkit that consists of several elements. In Figure 30 the complete toolkit in use is shown. The idea behind this toolkit is that it creates a joint activity whereby a former graduate, a new graduate, and a manager of UI sit together and work on different exercises that help them to share tacit knowledge. All the different elements of the toolkit are described separately with an explanation of the design decisions that link to findings gathered from theory and exploratory research.

The guide

The guide is a booklet with exercises that help the participants to discuss all the important subjects and makes the toolkit a stand-alone design that can be used without the need of a facilitator. Because the use of the toolkit is not intuitive and a specific type of knowledge should be transferred, guidance is important. From test 2 (see Chapter 4.2) it was observed that it is hard for participants to start. Therefore, the guide can provide support and motivation to start building. The complete guide can be found in Appendix F. The guide is divided into three parts that all have different goals and different exercises:

- The warming-up round consists of two individual exercises and one group exercise that aims at getting to know the elements in the toolkit. The idea of the toolkit is that all participants together actively engage in the building process. Therefore, a warming-up exercise that needs to be performed as a group can help them to get used to this.
- Round 1 consists of exercises to explain the project of the former graduate. In these exercises, the problem statement, the stakeholders, and the process towards the solution are discussed. Also, the relation to the U-shaped learning curve of UI will be discussed.
- Round 2 consists of exercises to explain the project of the new graduate. In these exercises, the problem statement, the stakeholders, and the plans for the graduation project will be discussed. Also, here, the relation to the U-shaped learning curve of UI will be discussed.

In the guide, a timer has been added for all exercises. The timer helps participants to start building because they feel more pressure. In the explanation of the exercises, multiple times it is addressed that the participants should use the elements in the toolkit to answer the questions, meant to encourage them to keep building. The guide has been checked for clarity and unambiguity during a pilot.

Basic Elements

The basic elements can be used to build a composition. They consist of foam elements and wooden elements. To distinguish between different elements, the participants can use the dimensions size, and shape.

The foam elements are based on the reference objects of VormTaal (Kamp, 2018) and the findings that people missed rounded shapes and more of the same blocks in the block set used in test 2. The foam elements, therefore, have three different shapes and three different sizes. The idea behind these elements is that they can be used to represent stakeholders or places in the neighborhood. The sizes of these elements are based on the size people can hold in one hand. Limitation of the dimension of the elements to this size does not only make it easier to build, but it also provides participants the possibility to perform exploratory procedures. Performing these procedures would not be possible if the elements would need to be held with two hands.

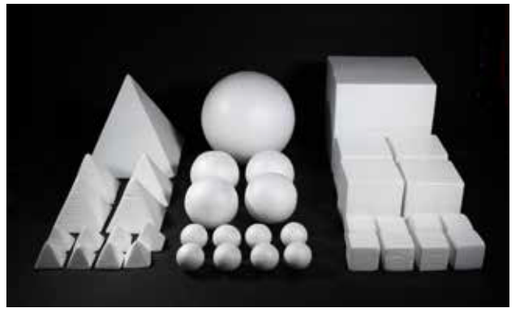


Figure 26. Basic elements - foam elements

Figure 27. Basic elements - wooden elements

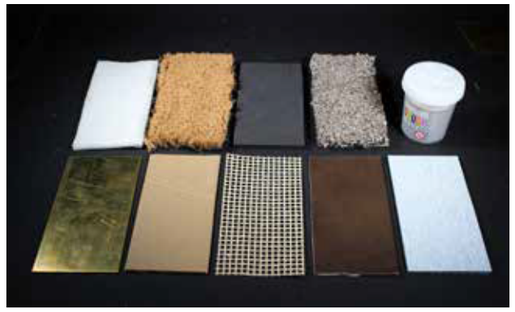


Figure 28. Haptic elements - different textures

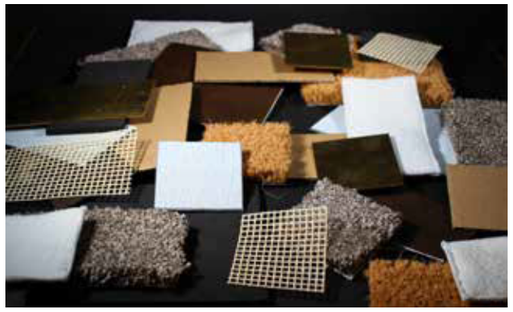


Figure 29. Haptic elements - different sizes

The wooden elements are based on the planar and structural elements of VormTaal (Kamp, 2018). The wooden elements consist of bars in two different sizes and flat plates in three different shapes.
These elements can be used to build stable compositions.

Haptic Elements

The haptic elements can be used to enhance the composition with an abstract layer. Abstract thinking is the ability to imagine concepts beyond what is observed physically. The haptic elements consist of nine different materials and eight of them are available in three different sizes and one in only one size Also, two little jars of clay are added for viscosity and stickiness. The elements can be used to indicate how certain relations between stakeholders feel, for example, sandpaper can be used to indicate a rough relationship while messing can be used to indicate a smooth relationship.

For selecting materials, the paper of Bergmann, Tiest & Kappers (2006) was used. They have mapped the haptic perception of materials on two different parameters, compressibility (hard/soft) and roughness (rough/smooth) using multi-dimensional scaling (MDS) as shown in Figure 31. In this Figure, a couple of material categories can be found that were all tried to be integrated into the prototype to have the full range of haptic perception of materials. The materials were selected to cover as many as possible different properties that people can feel: temperature (warm & cold), rough, smooth, sticky, hard, soft, fluffy, prickly, or rippled. Therefore, the following materials were selected for the prototype: fabric (soft, warm, and fluffy), sandpaper (rough and rippled), leather (smooth), messing (smooth and cold), coconut fibers (prickly, hard, and rippled), tapestry (soft and rigid), flexible mesh (rippled) and clay (sticky and viscous). All haptic materials of the toolkit fall into the same color palette, see Figure 28. Consequently, less distinction

will be made on the color of the materials, which is a visual dimension.

The size of the haptic elements is made slightly bigger compared to the size of the basic elements to allow the haptic elements to be visible when basic elements are placed on top. The decision was made to make the haptic elements flat to eliminate the dominant dimension of shape that is preferred to be explored by sight. The focus should be more on texture, a dimension that is preferred to be explored by touch.

Bottom cover
The bottom cover is an A1 sheet of white paper with lines drawn on it to provide the participants with a structure. This cover was included to give the participants a clear place for building and a starting point based on the finding that the participants of test 2 found it hard to start building. The cover could also be used to draw or write on.

Post-its & a pencil
The post-its and a pencil are added to the toolkit to allow the participants to label elements. During test 2 it became clear that some participants forgot halfway what the values were that they had assigned to some of the blocks. This disrupted the flow of the session and made the composition that was built less clear.

A little box with cards
The little box with cards contains cards with random nouns that are used for the warming-up exercises. By using multiple random cards, instead of telling the participants in the instructions to build a duck, the participants can experience different ways of using the elements because more options will be presented in the different compositions. Furthermore, it keeps the warming-up exercises interesting in case participants would use the tool multiple times.

Preparation exercise in Miro
Before the session with the toolkit, the students were asked to prepare an assignment in Miro to let them think about their process of their graduation project. From context mapping, it is known that people need to be eased into a subject before they can reach the level of tacit knowledge. From the creative session, it was retrieved that it is hard for people to talk about their learnings when they did not have had a reflection moment to become aware of their own experiences. In this case, the preparation can help the students to take a step back from their graduation project and to reflect on their progress and learnings.

The second reason why the preparation assignment is included is that it can help to uncover if tacit knowledge is shared during the session. By comparing the topics that were discussed in the preparation exercises with the topics discussed during the actual sessions, differences can be found. When new topics were discussed that the students did not think of before, tacit knowledge could be shared.

5.2 Method

The prototype has been tested with two different groups to validate if the thoughts behind the design match with what is observed in real-life usage. The prototype was created based on the idea that with haptic elements a deeper level of knowledge, tacit knowledge, can be shared between students.

The first group consisted of a graduate student that started in September 2020 and almost finished his graduation, a graduate that started in February 2021 and was at the beginning of his process, and Elma Oosthoek, one of the managers of UI. The second group consisted of a minor student that had finished his project in January 2021, a graduate that started in February 2021 and was at the beginning of his process, and Angela van der Heijden, one of the managers of UI. The tests were designed as stand-alone tests, meaning that there was no facilitator and there was no one to turn to for questions. The participants got the instructions to do what they thought was meant in the guide. After the session was finished, the students were asked to fill in an evaluation form (see Appendix G).

To evaluate the results, an observation list was created based on the theoretical background (Chapter 2) and the theory on haptics (Chapter 3) and can be found in Appendix H. The video and audio fragments that were recorded during the sessions were used to observe what happened. The evaluation forms were used to check if the observations were interpreted correctly.

Figure 30. Close-up of the prototype in use

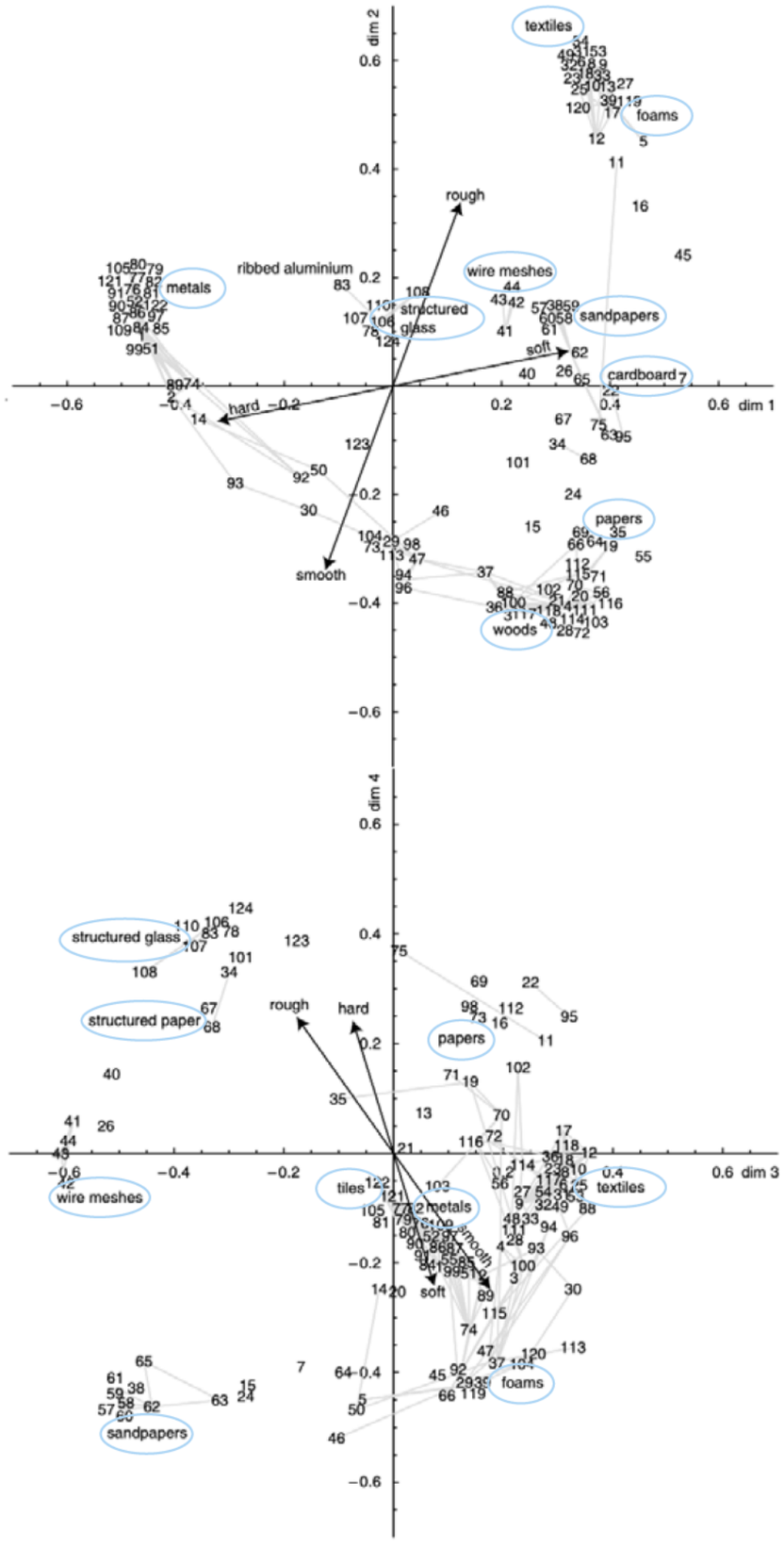


Figure 31. Four-dimensional MDS configuration (2 dimensions per plot). The light lines connect stimuli with a dissimilarity of less than 0.4. The arrows labeled 'hard/soft' and 'smooth/rough' indicate the fitted vectors representing compressibility and roughness, respectively. (Bergmann, Tiest & Kappers, 2006)

5.3 Hypotheses

1. The haptic elements will be explored more extensively and attract more attention compared to the structural elements when the participants are asked to unpack the box.
2. Because there is a difference in structural elements and haptic elements, the haptic dimension of texture will be more involved in the conversation compared to test 2 in which they were part of the blocks. This means that the feeling of the textures will be more expressed and used to explain things.
3. There will be a difference between the values that will be given to the structural elements compared to the haptic elements.
4. The structural elements will be used to explain concrete values, while the haptic elements will be used to explain abstract values like emotions or words like 'peace' that are too complex to understand.
5. The haptic elements will be explored at the same time by multiple participants when a haptic element is used in the discussion to make a point.
6. There is more interaction with the haptic elements compared to the interaction with the structural elements.
7. When the shared insights from the preparation exercise are compared with the insights shared in the test, the insights in the test will be more elaborated and different compared to the ones in the preparation.
8. All participants will at least have one new insight after the use of the tool.

5.4 Findings & Discussion

In this paragraph, the most interesting findings of the prototype test are discussed with examples. Also, the relation to theory is discussed and what the results indicate for further development of the haptic language design.

To establish learning and to create a learning community, Wenger (2000) explains that **personal experience** and **social competence** need to be in tension. Social competence means that the participants acknowledge the knowledge of other participants. For example, in the first session when the participants discussed the overlap between the two different problem statements, the new graduate asked the former graduate: "*What do you recognize in my story?*". By asking a question about someone else's view or opinion, the participant acknowledged the competence of the former graduate, while also looking for common ground. Another example is when the new graduate in the first session asked: "*Are there any other additions on this subject?*". This indicates that the new graduate is curious and values the input of the other participants as otherwise, he would not have asked such a question. An example from the second session is when the instructions of the first round in the guide were not completely clear. The new graduate asked for confirmation from the other participants. Together they discussed what they thought should happen and when they all agreed they continued with the building part. These examples indicate that in both sessions the participants acknowledged each other's social competence.

Personal experience means that people can express what they have been through and share personal stories. For example, in the first session, the new graduate shared a story about the time he worked in a restaurant and how they had to prepare the tables for the guests. Another example from the first session is the manager that explained that she could relate to the new graduate because she also had too much data during her graduation. In the second session, only one personal experience was shared when the former graduate explained that he let people measure the heat themselves with equipment to experience it first-hand during his project. This is only one personal story in one out of 9 different exercises. In the first session, 6 out of 8 exercises evoked many personal stories.

From the first session, it was noted that often personal stories and experiences follow up on each other. When one of the participants started sharing a personal experience, other participants also wanted to share their personal experiences related to that subject. Telling personal stories had a so-called snowball

effect. It is often in these personal experiences that experiential knowledge is shared which is the knowledge UI wants to preserve in their learning community. Therefore, it is important to pay attention to how the sharing of personal stories can be evoked because the prototype does not necessarily evoke sharing these stories.

To get an idea if the two concepts of personal experience and social competence are in tension to establish learning, the students were asked in the evaluation forms to rate how the problem statements connected and how the knowledge of both students connected. The mean score of the connected problem statement was 3 on a scale of 1 to 5. This indicates that the problem statements are connected enough to provide overlap to talk about, but also disconnected enough to create interesting learning opportunities. The mean score of the connected knowledge was 3.5 on a scale of 1 to 5. This indicates that there was enough overlap to bridge the knowledge boundary, but also enough room to learn from each other. With these scores from the evaluation form, it could be concluded that tension was created, and, therefore, learning opportunities were provided.

Besides the tension between competence and experience, there are three modes of belonging that indicate if someone participates in social learning. Only the first mode, **engagement**, was observed. Engagement means doing things together, listening to each other, and interacting with each other. This can be seen by participants nodding, asking questions, and if they all actively contribute to building. In both sessions, the participants indeed nodded and looked at each other when someone was talking during the whole session. Furthermore, all participants asked questions in both sessions. The active contribution to building was only seen in the first session. During the second session, all elements of the prototype were placed in the middle of the bottom cover, leaving no clear space to build. Therefore, the building happened in front of each participant giving the other participants no room to actively engage in the building process.

Looking at the additions made to the compositions by other participants during the first session, they indicated that these additions can spark new ideas. For example, during the first session, the former graduate was explaining how he tackled a setback in his process while in the meantime the new graduate added something to the composition. When the former graduate finished his story, the new graduate explained what he built: "*You told about the blockade and that you started looking what you could do next. Then you talked with someone that was your inspiration that helped you to build a new foundation on which you could continue your project*." The reaction of the former graduate was: "*yeah, very nice*" and he immediately continued building. Later on, a similar effect was observed when the manager added something to the composition of the former graduate. This also sparked the former graduate to build something else. Not only the sharing of personal stories seem to have a snowball effect, but also the building of others can inspire the participants with new ideas. However, this did not happen in the second session. The new graduate two times added something to the composition of the former graduate, but it did not seem to inspire the former graduate because nothing happened after the additions were made. This could indicate that interaction with the composition is important to keep the conversation and, therefore, the learning going.

Another clear example that showed that engagement was present during the first session, is that when the participants were cleaning the building space after an exercise, the former graduate wanted to add something to his story that just popped into his head. While he started explaining, the new graduate stopped cleaning and focused his attention on the story of the former graduate. Only when the former graduate was finished with his story, the new graduate started cleaning again. This also indicates that the new graduate valued what the former graduate was telling, another example of acknowledging competence.

What is surprising from the second test, is that when the former graduate had explained his problem statement, and the new graduate already two times asked: "*So, your problem statement is ...*?" for clarification, yet the manager asked if the problem statement was clear for the new graduate. The new graduate answered doubtfully with a yes and then quickly started reading the next exercise. The manager nor the former graduate reacted to this doubtful answer. Hereafter, it seems like the new graduate lost his interest in the story of the former graduate. He more and more often picked up elements to play with them and he did not ask as many questions as he did before. When something is not clear, it will become harder for participants to understand and, therefore, less interesting. When the engagement of the new graduate got lower, it became harder for him to learn something. Therefore, it is important to have moments to check if everybody still understands what is being told to keep the engagement level high.

From these results, it can be stated that during both sessions the participants were engaged, however, in the first session the level of engagement seemed to be higher because of the involvement in building during the whole session.

To describe the process of transdisciplinary learning, Müller et al. (2005) proposed a three-step learning cycle whereby people have their interpretations of the world that can shift again after the creative step and the descriptive step have been executed. The first step is the **normative step** which relates to the personal experiences and social competencies that the participants bring to the session.

The **creative step** is about creating ideas, proposing actions, and testing theories and is obvious when participants propose actions to themselves or others. During both sessions, the participants exchanged tips, for example, the manager in the first session talked about an interesting report that the new graduate should read and indicated that she will share it with him. Another example is that in both sessions the former graduate's proposed new stakeholders for the new graduate to talk to. Sharing these tips can stimulate the new graduate to have new insights and to learn new things outside the session. Another concrete example that shows that the creative step is happening during the use of the prototype is that in the first session the manager said to the new graduate: "*We should talk again, to see how we can make your research smaller*." This is the proposition of a concrete next step that the new graduate should take in his process.

An example that the creative step is connected with the descriptive step is that in the first session the manager took a piece of gaze to add to the composition of the former graduate, but before she placed it in the composition, she asked if the former graduate would agree. The manager proposed an idea and by asking if the former graduate agreed, she forced him to think about it. The former graduate needed to perform the descriptive step in which he analyzed the new situation and formed an opinion. This is also an extra reflection moment for the former graduate.

The **descriptive step** is about observing and analyzing the insights gained from the ideas and actions in the creative step and create new knowledge out of it. This also includes reflection that is part of **metacognitive skills** that are necessary for transdisciplinary learning. This happened multiple times in the sessions. For example, when the participants in the first session were cleaning and talking after one of the warming-up exercises, the former graduate had a new insight: "*maybe that's the reason I wanted to go to the social enterprises, I need that to experience it, to surrender myself.*" This insight was gained in the conversation after the explanation of the exercises and was a reflection of the student on his actions.

Another example that shows that the participants can reflect on themselves is when the manager in the first session proposed that the new graduate should make his research smaller. The new graduate reacted: "*I know that is a problem, I am too visionary in that sense, I want too much. I like it to go abroad and get a lot of information because it is so interesting.*" The manager reacted: "*It might be interesting, but not relevant*." In this conversation, the new graduate could reflect on himself. The interesting part for the manager is that in this type of conversation, the manager gets to know the students and their pitfalls. In this way, the manager will be able to coach the student better in the future. This is relevant learning for the manager.

Another interesting example shows how the manager reflects on the story of the former graduate: "*But it is maybe what happens here* (points to the clay in the composition), *that you feel like you look again at a lump of clay, while you might be able to start to knead again. You have all these moments in which it seems to scare you.*" After this conclusion of the manager,

the former graduate leaned back in his chair and took some time to think and react: "*maybe that comes from my education, they talk a lot about thresholds, which are not there to block you, but to overcome*." The view of the manager on the story of the former graduate makes the former graduate think about his process and the reason he could be 'scared'. In other words, the reflection of the manager helps the former graduate to reflect on himself.

Besides metacognitive skills, there are the **7 Habits of the Mind** (Mishra et al., 2011) that describe the important individual skills for transdisciplinary learning. To enhance transdisciplinary learning, the 7 habits of the mind must be enhanced by the use of the haptic language.

The first habit of the mind is **perceiving**, which means understanding something by paying attention to information that is gathered through the five senses. With a haptic language design, the focus should be on touch experiences. However, touch experiences are not often named during the sessions. There is an example from the first session that the manager explained that the tapestry feels homely, which is one of the contexts in which the cutlery is used. For the final design, more attention must be paid to addressing touch experiences.

The second habit of the mind is **patterning**, which means recognizing patterns or creating them. There is one clear example in the data of patterning. When the former graduate had told his story of the process in the first session, the manager added something to the construction and recognized a pattern. She explained: "*I added the coconut fiber and the fabric at this place in the process because it looks like you went through the same learning cycle together with the 'Ruilwinkel' as you have done on your own. So, first, it sands* (coconut fiber), *then you pamper them* (fabric), *and then comes the insight or the price* (manager adds a messing plate). *You see yourself having these steps at the beginning as well* (points to the first part of the composition)." Because the idea of the session was to share relevant knowledge, it is interesting to look for similarities and differences. By analyzing them, one can learn a lot. Therefore, patterning should be more present in the final concept design, for example by letting the participants both built their problem statements at the same time to make comparing easier.

The third habit of the mind is **abstracting**, which means capturing the essence of something. There are two clear examples of analogies that were used during the first session in the third warming-up exercise in which the participants had to build a composition together and later explain why the composition resembled the card they took from the card box. The first analogy came from the new graduate that explains why the composition that they built together resembles a pear. First, he compared the appearance of a pear with that of the composition, but then he explained: "*At EMI we want to force the big complex issue, that includes multiple smaller problems to the top of the pear, which is smaller because then the problem is easier to understand*." He used the pear with the construction to compare how EMI wants to solve complex urban problems. The second analogy comes from the manager that explained why the composition that they built together resembles a butterfly: "*a butterfly has many colors and wants to explore a different flower every time. The butterfly wants to explore and understand the whole field and, therefore, he picks up a lot of nutrition which he can put somewhere else and that resembles the students that graduate at UI.*" She compared butterflies and how they work with the graduate students of UI.

The fourth habit of the mind is **embodied thinking** that involves thinking with the whole body which means using all senses to gather information but also empathizing with others and understanding someone's point of view. Besides the haptic usage of the tool that is related to this habit and is discussed later on in this chapter, there is an example of embodied thinking from the second session. During the explanations of the third warming-up exercise in which the participants built a composition together, the manager asked if the students had any additions to her explanation. What happened, was that both students started looking at the composition from different angles. They physically tried to take another perspective. This also happened during the first session in which the manager during an explanation of the former graduate stood up to get a better look at this composition. These examples show that the participants were using their vision to create new perspectives that could inspire them and could be interesting to take into account for the final design.

The fifth habit of the mind is **modeling** that involves creating representations of something to study it. This is the basis of the toolkit, i.e. to model representations of the problem statement and the stakeholder network to study what happened during the graduation process of the former graduate. But it also involves if participants try out different ways of building and if they adjust the composition during the session. For example, in the second session, one of the students tried something with the foam elements, but it did not hold and he switched to using the wooden elements instead. He changed the plan. Another example from the second session: while the former graduate was explaining his problem statement, he removed the residents from the composition. He made adjustments to his composition to make his story clearer for the other participants. Earlier in this chapter, examples were given that relate to other participants adding elements to the composition, which are also examples of modeling.

The sixth habit of the mind is **deep play** which involves having 'fun' to create new insights and ideas. From the prototype perspective, the warming-up exercises are all for fun, to get an idea of how the tool works. During the warming-up exercises, the participants were laughing and playing. For example, in the first session, the participants were building a composition together without meaning. The manager placed a sphere on top of the compositions and let it roll off just for fun and to tease the other participants a bit. From the comments that were given on the prototype, in general, it could be deduced that participants perceived the usage of the prototype as fun, for example, the manager said: "*very nice, Jolien, very nice way of interacting with each other*."

The seventh habit of the mind is **synthesizing** that involves combining the previous habits, that all create new knowledge differently, into a whole. This relates to the descriptive step that also includes creating new knowledge out of everything that is observed. During the sessions, this happened when participants summarized what they had heard, seen, and felt. For example, in the first session, when the new graduate had built his problem statement and explained it, the manager asked: "*If I understand correctly, I hear you say that you want to use …*" The manager was trying to connect all the dots for herself to see if she understood what the new graduate was telling. Doing so, she used what she had heard and seen but also what she had observed during the whole exercise. In the second session, the same happened when the new graduate asked the former graduate: "*So, the problem statement is …* ". He tried to tell the story of the former graduate in his own words. These examples also indicate that the participants were eager to understand each other and felt engaged. The process of synthesizing and the descriptive step continue after the session was finished.

The 7 habits of the mind, the metacognitive skills, and the three-step learning cycle that all seem to be present during the sessions indicate that **transdisciplinary learning** has taken place. However, there are also some other indications from the result that demonstrate that the participants learned. For example, during the first session the timer went off to indicate that the exercise was finished, but the new graduate said: "*We can finish this conversation!*". This indicates that the new graduate thought the conversation was interesting and that there was more to talk about. He probably felt he was learning something.

Another action that shows that learning happened, at least in the first session, is that all the participants in the first session made notes. For example, when the former graduate was sharing a personal experience about what the different stakeholders had told him, the new graduate picked up the word 'ownership'. He started talking about what he feels ownership means and he wrote something down. This indicates that the new graduate had an insight that could be relevant and that he wanted to remember.

An example that shows how learning can be killed is when in the second session the former graduate said: "*For the rest, I would not know, I don't know that neighborhood very well*." The new graduate replied: "D*o you want to know more about stakeholders for your project*?". The statement of the former graduate

shuts the door for further learning. By stating he does not know, the new graduate probably feels there is nothing to talk about anymore and nothing to learn and that is why he changed the subject to the project of the former graduate again.

From theory, it was also indicated that the type of knowledge that should be shared during usage of the haptic language is **tacit knowledge** which is hard to explain by only words. It is hard to know if tacit knowledge was shared, but there is one clear example in which the new graduate in the second session had trouble with explaining the composition about himself. He said: "I *have built something more related to my values, I guess. I thought I use materials that have similarities but are also different and with those materials, I tried to portray my interests, which can be very different but can end up in the same direction. Uhm, how do I explain this.*" He had a couple of breaks in his explanation and tried to find the right words. He also said at the end that he was not sure how he could explain this, but he had found a way to express it with the prototype. This could indicate that the prototype can help participants to express something that is not easily shared in spoken words.

Indications for the sharing of tacit knowledge were also found by analyzing the differences between the topics discussed in the **preparation exercises** and during the session. By comparing the topics, differences between the preparation exercises and the session could indicate that new knowledge was created. In the first session, for both problems, there were some topics discussed that were not mentioned in the preparation exercises, like '*waking people up*' or '*festival experience*'. For the second session, this was not the case. This could mean that in the first session new insights were gathered and tacit knowledge was shared, while for the second session the level of tacit knowledge was not reached.

Because the preparation exercise was also included as a research tool, it needs to be evaluated to see if it adds value to the final concept design. From the evaluation forms, it became clear that especially the former graduates found that the preparation exercise helped to make the problem statement and their process clear in their head; "*To get my problem statement clear and what the possible solutions are*". On the other hand, all students indicated that the insights that they got from the preparation exercise were not surprising, more confirmatory.

Another observation from the sessions is that **the managers** also have a lot of knowledge about the process of the graduates. As already mentioned, the manager was often asked for confirmation. Besides, the managers asked critical questions to let the students reflect on their process, for example: "*Where was the municipality? Or don't you think that's a stakeholder?*". This shows that the managers have a crucial role in the transfer of knowledge from one student to the other. Not only do they function as extra 'experts' on the processes of the graduate students, but they also translate from one student to the other. For example, in the second session, the participants talked about 'livability' when the manager asked the new graduate: "*Do you know what livability means from the perspective of the former graduate because I can imagine it means something different for both of you?*". She also asked questions to make it more clear for the new graduate like "*You mean the municipality at a distance, right? Not the people that work here in the neighborhood?*". With the managers as extra experts and the notion that the preparation exercises did not deliver new insights, the preparation exercise might not be needed when the managers are actively involved during the session. Based on these observations, it could be concluded that the role of the managers is essential to establish learning in all situations. Even when a student is reluctant to share information, the manager can ask questions to bring interesting knowledge to the surface. The new graduate does not possess knowledge about the process of the former graduate and, therefore, is not able to ask the right questions.

Another important aspect of the prototype is the **haptic elements** and how the **haptic dimensions** were used during the session. Integration of the haptic elements was thought to stimulate exploration at the beginning of the session when the toolkit was unpacked, but this was not the case. The participants seemed overwhelmed with the number of elements and tried to unpack the box as quickly as possible. For example, in the second session, they flipped over the box halfway to empty it quicker. This could indicate that the participants are already aware of how things might feel or that the instructions should be adjusted to make room for exploration. It could also indicate that there are too many elements that overwhelm the participants. Therefore, the final design needs to be simplified.

However, while exploration was not happening during the unpacking, in both sessions at many different moments it has been observed that participants felt elements or took the elements in their hands. Sometimes, the participants took a closer look at the elements or stroked them.

The haptic elements were used in different ways. For example, they were used to indicate different stakeholders or to represent grass (coconut fiber). But they were mostly used to indicate how something felt, like a smooth beginning (leather) or something homely (tapestry). Another example is one of the participants using coconut fiber to explain: *"it started a bit edgy*". Looking at these examples, it seems like the haptic elements represent more abstract values when they are chosen for how they feel (tapestry feels homely) compared to more literal values when they are chosen for how they look (coconut fiber looks like grass).

The visual dimensions of the elements cannot be fully eliminated. Even though all the colors of the haptic materials were kept in one color palette to make the distinguishing color less tempting, color was still used as a feature to choose a certain element. For example, the messing plate was used to indicate 'a golden price' or 'a golden horizon'. Furthermore, the post-its, the only item with a very different color, were used to indicate a new beginning because of the fresh and different color.

Other interesting insights were gained from observing the building process of the participants. They could be divided into two different approaches. The first approach was to build first and then explain, the second approach was to build while explaining. The first approach was forced upon the participants during the warming-up exercises, but during round 1 and round 2, the participants did not receive clear instructions of when to build and when to explain. The difference between the approaches is that the first approach seems to produce more insights. As the new graduate explained after the warming-up exercises: "*It is funny, in 30 seconds you think of something to build without having deep thoughts about it, but there is more to it when you start explaining it. I think that is interesting of this kind of conversation, you will never have those conversations without the building part.*" And as explained before, the former graduate in the first session added insight to his story after everyone was done explaining.

The first approach, i.e. first building and then explaining, seems to give room to change the values of the elements and make them more concrete. For example, during the first session, the new graduate started building by adding some different textures to the composition to indicate different stakeholders. Later on, in the explanation, the different textures became specific stakeholders by naming that tapestry stood for the 'Hand-in-hand alliantie', for example. In the end, the values shifted again and they became different disciplines instead of stakeholders.

When the participants were building while explaining, the conversation became more traced. For example, during the first session, the former graduate was talking about his process and named a new stakeholder that made him think of the 'pyramid of Maslow' and he chose a pyramid to resemble it. This order seems to shut down the learning process in the way that the element is what it is. When the participants would first be forced to build and only then start explaining and adding things to the composition, it might be that there is more room for new thoughts that bring new insights and, therefore, enhance learning.

Looking at the insights of building approaches, it was noticed that the added value of using something like a haptic language lies in creating an extra thinking step. Building a composition is the first time participants need to think about what they want to tell. When they start explaining their composition to the other participants, they have a second moment to think about their story and to change it. This is an extra moment of reflecting on oneself and one's story and can evoke new insights.

Another insight retrieved from the observations that are related to the building process is that taking the time to think about what you want to build can lead to new insights. For example, during the warming-up in the second session, the former graduate needed to build a telephone. He was the only one that took around 20 seconds to look around and think before he started building. He later explained: "*My first idea of a telephone was a smartphone, but they are very straightforward and boring to build, so I thought of building the old telephones with a horn*." From other observations, it became clear that the first idea that pops up in people's minds is often a literal representation, the obvious choice. But when participants take more time to think, one sees them building the context or a deeper connection they have with the word. When participants directly start to build, the constructions represent literal, obvious representations like houses, but when they take more time before starting to build, the compositions become more interesting.

Finally, during the second session, all the different exercises of round 1 and round 2 were built separately instead of including everything in one composition. Therefore, it was hard to link everything together and to see the whole picture. Synthesizing becomes harder and, therefore, learning becomes less likely. With the notion that it felt like in the second session fewer new insights were gathered, this could indicate that it is important to try to combine all the knowledge by creating one composition. This will make it easier for participants to see the links between all the elements of the problem statement and will make it easier to learn.

5.5 Design take-aways

From the prototype test, different ideas were obtained that are interesting and useful for a haptic language design for UI. In this paragraph, these ideas are presented as design takeaways to be considered for the final concept design.

1. Clear instructions for haptic usage

Haptic usage does not happen consciously. If haptic usage is the goal, it should be explained and stimulated. Explaining can mean introducing the haptic dimensions weight, temperature, and texture and letting people experience how these haptic dimensions can be used in communication via exercises that focus on these dimensions. This can for example be done by comparing exercises of two elements, e.g., 'if you compare these two textures, which one feels better for stakeholder X and why?'. Stimulation can be done by repeating comparison exercises during the different topics that will be discussed. These comparison exercises can be put into a guide that is delivered with the haptic language design.

2. More focus on 7 habits of the mind for transdisciplinary learning

While all 7 habits of the mind are found in the data, they were not consciously taken into account for the prototype design. From the prototype test, it became clear that they are important for creating new insights and, therefore, for learning. Consequently, the 7 habits of the mind should be taken into account for the final concept design whereby observing, abstracting, patterning, and embodied thinking are the most important. Consciously adding these habits can be done for example by having the compositions of both graduate students on the table at the same time to easier see the similarities and the differences between them.

3. More focus on haptic dimensions

Visual dimensions are still very dominant. The haptic elements are still picked because of their color or because they look different and not as often on how they feel. Size did not seem to matter for the haptic elements. Therefore, even less focus on visual dimensions by making haptic elements one size and making the basic elements consist out of only one shape, for example, cubes, can help to bring the haptic dimensions more to the surface. Fewer options in shape can maybe also enhance abstract thinking and can maybe stimulate the use of clay.

4. Guidance for abstract usage

People find it hard to reach a level of abstract thinking on their own, they stick with a more literal approach to building (building houses, like in the second session). To reach more abstract usage, participants can be guided with the right questions and exercises, for example, comparison exercises or blind feeling of elements. Furthermore, participants can be stimulated to take some time to think before they start building. From observations, it is retrieved that 'how an element feels' is often used to express abstract values, while 'how an element looks' is often used to express literal values.

5. Stimulation for abstract building

Abstract building can lead to more questions that are asked because things are more unclear at first. By asking questions, more and more personal stories and experiences will be shared. These in return will trigger other participants to also tell their personal stories and experiences. In the personal stories and experiences, the tacit knowledge is shared and that is the core of the haptic language design for UI.

6. Stimulation for building first

By first building a 'rough' composition, a first thinking cycle is activated among the participants. When they start explaining they will activate a second thinking cycle which is a reflection on their first ideas and can bring new insights. It opens up the conversation and the possibility to learn. The value of elements can shift more easily because it feels like a sketch, not a final presentation drawing.

7. Process of the students contain most interesting experiential knowledge to transfer

During the first session, it became clear that the process of the former graduate was the most interesting topic to discuss and was connected to the problem statement and stakeholders as well. For the usage of the haptic language design for UI, the process of the former graduate would be the most valuable to discuss, since this knowledge contains the most tacit knowledge that needs to be shared and transferred.

8. Focus on sharing personal experiences

In personal experiences shelters experiential knowledge that UI wants to preserve. From data, it has been found that when personal experiences are shared, more stories of other participants follow. Also, during the sharing of personal experiences, notes were made by the participants in the first test, indicating that during these interactions people gather new insights. In the second session, hardly any personal experiences were shared, and nothing was written down. Personal stories inspire.

5.6 Conclusion

Combining all the observations and the data with the hypotheses, we can conclude that the haptic elements did not evoke exploration or attracted more attention during unpacking the toolkit. Also, the haptic elements were not explored at the same time by multiple participants during the session and, therefore, there is not more interaction with the haptic elements compared to the structural elements.

During the sessions, the haptic elements were used for both their looks and how they feel. Compared to test 2 (see Chapter 4.2), the feeling of textures is somewhat more used to explain something, but this was still very minimal and should be enhanced in the final design. The haptic dimension texture is not structurally involved more often when they are separated from the blocks. There was no structural difference found in the values that are given to the structural elements and the values that are given to the haptic elements, but the haptic elements are used for more abstract values compared to the basic elements that are used for literal representations. Therefore, it can be stated that the haptic elements are used to explain abstract values.

The preparation exercise before the session was perceived as helpful by the former graduates, but is not necessary when the managers are involved, because they possess the knowledge to help the former graduates to get an overview of their process and learnings. The insights gained during the preparation exercises were not surprising and not distinctive enough compared to the insights gained during the session. Therefore, the preparation exercise is not needed to include in the final design.

Overall, all participants felt the use of the toolkit was useful and helped them to gain new insights about their graduation process or problem statement. All participants gained at least one new insight with the use of the tool and they like to use it again.

CHAPTER 5

KEY TAKEAWAYS

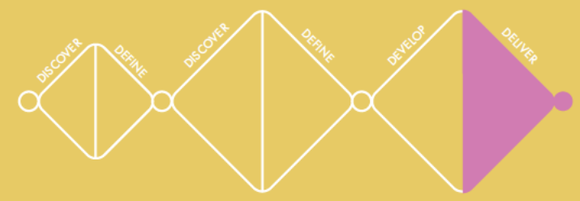
In this chapter, a prototype design has been developed in which all the findings gathered from theory and exploratory research are combined. With the prototype, research has been done into how haptics can contribute to the transfer of knowledge in the context of UI. Therefore, the prototype has been tested with two groups of two graduates and a manager of UI that are involved in consecutive projects, the proposed context for the haptic language design.

From the prototype test, different design takeaways are retrieved that must be included in the final design:

1. Clear instructions for haptic usage
2. More focus on 7 habits of the mind for transdisciplinary learning
3. More focus on haptic dimensions
4. Guidance for abstract usage
5. Stimulation for abstract building
6. Stimulation for building first
7. Process of the students contain most interesting experiential knowledge to transfer
8. Focus on sharing personal experiences

Furthermore, the findings within this chapter are used as input to develop haptic design principles that are described in the next chapter.

HAPTIC PRINCIPLES FOR TRANSDISCIPLINARY LEARNING



In this chapter, the insights that are obtained with exploratory research are combined with the insights from theory to define principles for haptic design for transdisciplinary learning. Chapter 2 described what is needed to share, transfer and preserve knowledge in a transdisciplinary context and chapter 3 described how the sense of touch works and how it is influenced by other senses. Afterward, chapter 4 showed a first indication of how haptics can be applied in communication. Last, chapter 5 showed how the insights from chapters 2, 3, and 4 could be applied in a first concept design. All insights from these chapters are combined in haptic principles for transdisciplinary learning. The principles guide future designers in their process of developing physical haptic designs for transdisciplinary learning.

This chapter first outlines an overview of all the principles. Thereafter, each principle is explained in more detail with ideas on how they can be applied in practice.

Haptic design makes people conscious of touch

Haptic design triggers people to touch it

Haptic design enables different touch experiences

Haptic design translates and adjusts between disciplines by providing the same meaning for everyone

Haptic design evokes interaction between users

Haptic design gives people the tools to make their thoughts and ideas tangible

Haptic design triggers people to touch it

The only way to experience touch, the basis of haptic design, is by actively touching something else. However, before the touching will take place, a first evaluation of the design will be made by sight. On this first impression, the decision is made if people want to explore the object further. Therefore, the haptic design needs to invite people based on the looks to start touching it. Touching the design also triggers observing and embodied thinking, 2 of the 7 habits of the mind that boost transdisciplinary learning. This can be done by using unusual shapes that are hard to imagine how they feel without touching, by using materials that do not reveal from sight how they feel, or by using touch to control something.

Figure 32. Idea sketches for the principle 'Haptic design triggers people to touch it'

Haptic design makes people conscious of touch

The whole day people experience touch without noticing it consciously because the sense of touch is very intuitive. When touch is used for learning, people must become aware of touch experiences. Furthermore, it has been observed that sight tends to be dominant to express knowledge. Therefore, people need to be made aware of how they experience touch. This can be done by focusing on the touch dimensions; shape, size, texture, weight, and temperature, or by providing clear instructions with the haptic design that help people to consciously experience touch. For example, an instruction to compare different textures and make a decision only on how something feels by asking a question like: "*which one feels better and why*?".

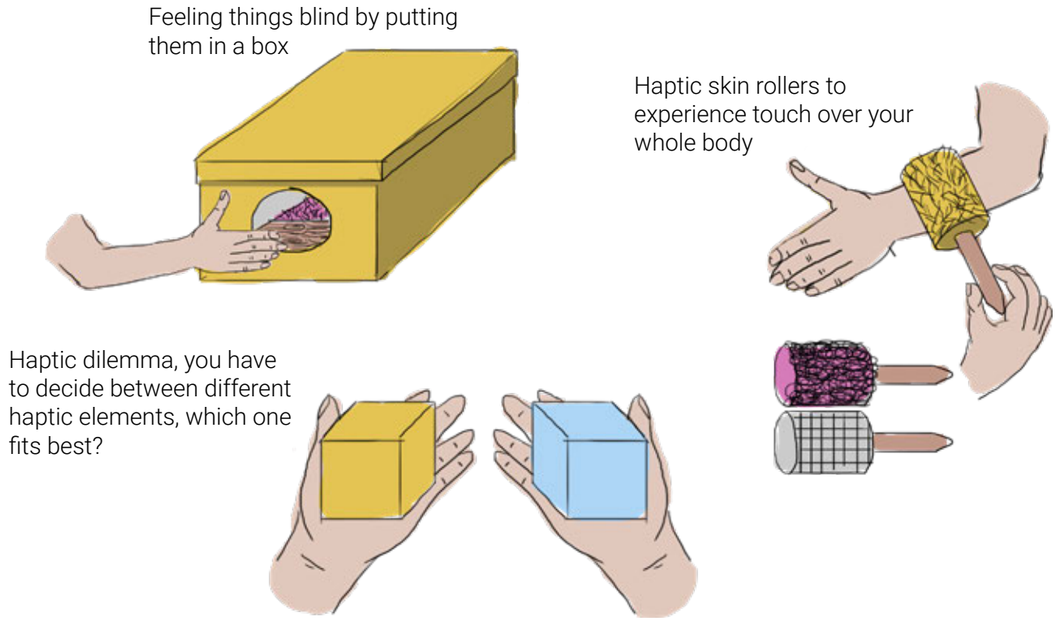


Figure 33. Idea sketches for the principle 'Haptic design makes people conscious of touch'

Haptic design enables different touch experiences

Objects from only one material and one shape are not interesting for longer touch explorations and do not trigger exploratory procedures. To create interesting touch experiences, it is important to combine the different touch dimensions shape, size, texture, weight, and temperature. Combining these dimensions invites the user to execute different exploratory procedures. This can be done by using different shapes that are interesting to explore with touch or by using different materials to combine different textures, weights, and temperatures.

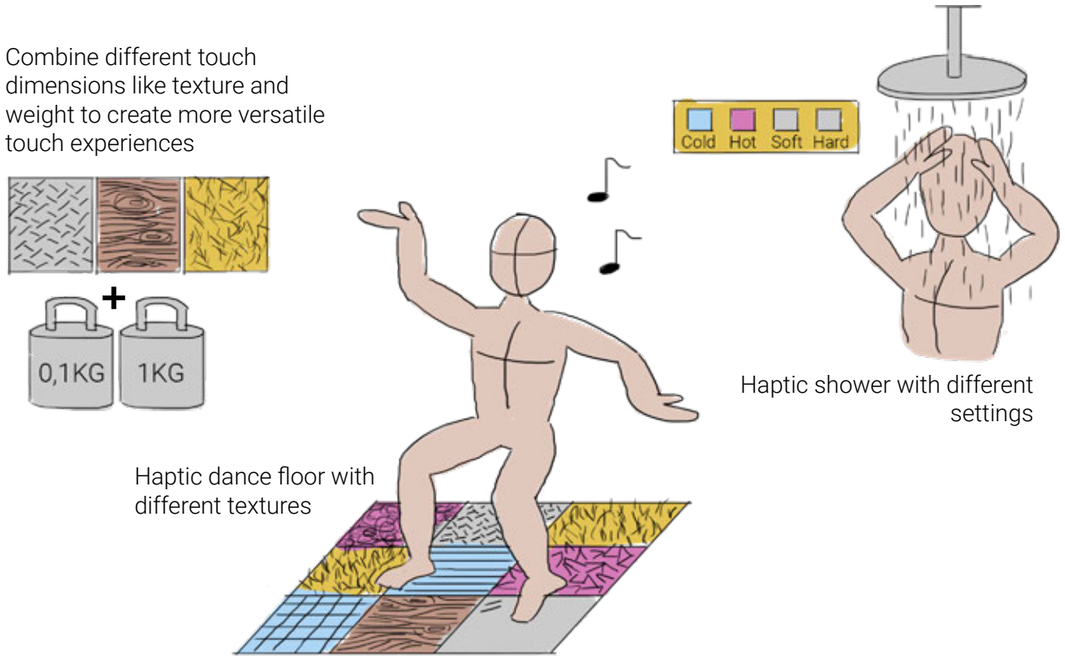


Figure 34. Idea sketches for the principle 'Haptic design enables different touch experiences'

Haptic design translates and adjusts between disciplines by providing the same meaning for everyone

Haptic design needs to be able to support multiple interactions between different social worlds so transdisciplinary learning can take place. Because people are from different social worlds, they will not speak the same language and they will experience a knowledge gap between them. To bridge the gap, knowledge boundaries need to be crossed. This bridging can be done with a boundary object, the haptic design. For boundary objects, it is known that they need to be flexible to be understandable in different social worlds, but robust enough to maintain the same meaning in one interaction. The meaning of the haptic design can be different for each interaction, as long as the meaning is the same for everyone within that interaction. This can be done by letting the users create the meaning of the haptic design themselves.

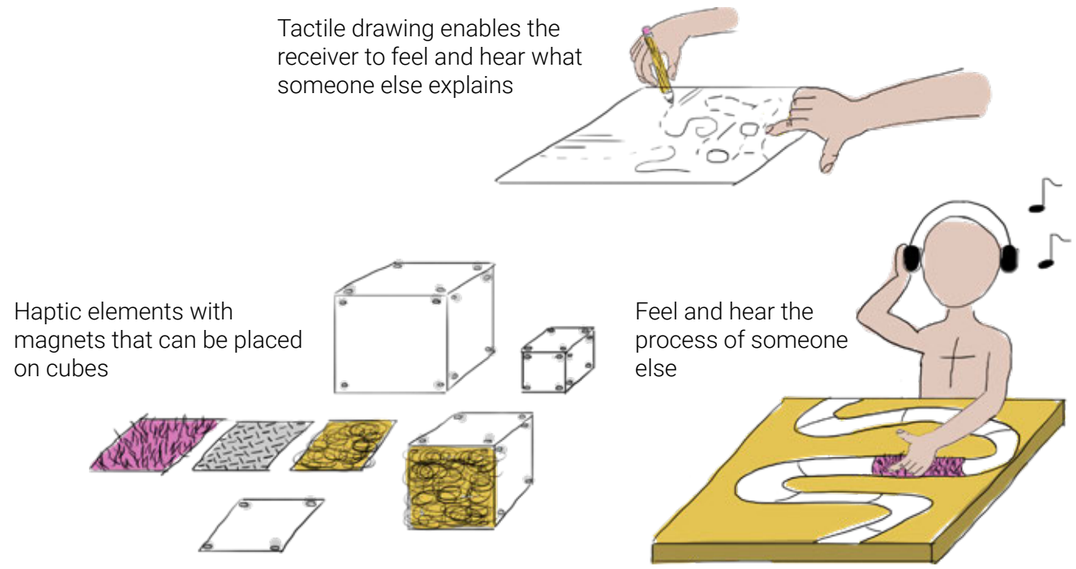
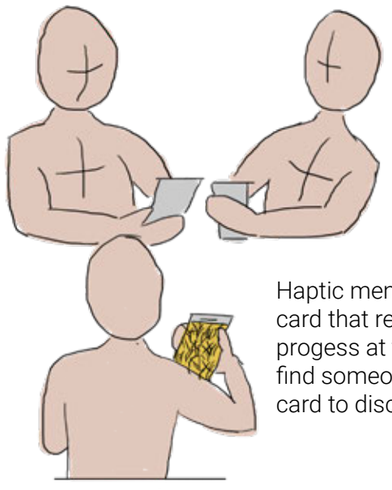


Figure 35. Idea sketches for the principle 'Haptic design translates and adjusts between disciplines by providing the same meaning for everyone'

Haptic design evokes interaction between users

By working together, people can get inspired by each other's ideas and can retain new insights. Joint activities and interaction are needed to establish a learning community and to bridge the knowledge boundaries. To create more learning opportunities within these joint activities, it is important to let the people work together with the haptic design. This can be by making it impossible to use on your own, or by making it a building kit that they can all use together to create something.



Haptic memory, pick a haptic card that represents your progess at the moment and find someone with the same card to discuss

'Stoelendans', change positions during the session with the haptic designt to literally change perspective

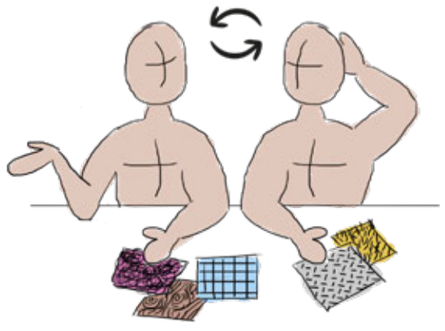


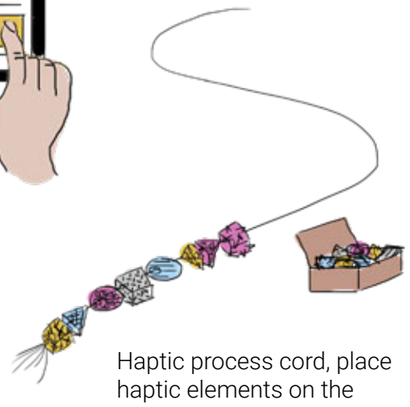
Figure 36. Idea sketches for the principle 'Haptic design evokes interaction between users'

Haptic design gives people the tools to make their thoughts and ideas tangible

For transdisciplinary learning, internal thoughts, ideas, and feelings must be made explicit so they can be shared with others. Therefore, the haptic design needs to be able to let people express their thoughts and ideas in a tangible form so others can see and feel them. Creating a physical form is also modeling, one of the 7 habits of the mind for transdisciplinary learning. This can be done by making the haptic design modular.

Haptic bracelet, with an application you can send feelings to someone else. Every feeling has a different vibration and temperature

Haptic bottle experience, "let it slip through your hands"



Haptic process cord, place haptic elements on the cord for every feeling you experience during the project

Figure 37. Idea sketches for the principle 'Haptic design gives people the tools to make their thoughts and ideas tangible'

CHAPTER 6

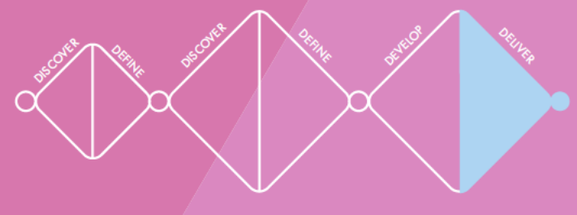
KEY TAKEAWAYS

This chapter outlines 6 haptic principles for transdisciplinary learning that designers can use to create haptic designs for transdisciplinary learning.

The 6 haptic principles are:

1. **Haptic design triggers people to touch it**
2. **Haptic design makes people conscious of touch**
3. **Haptic design enables different touch experiences**
4. **Haptic design translates and adjusts between different disciplines by providing the same meaning for everyone**
5. **Haptic design evokes interaction between users**
6. **Haptic design gives people the tools to make their thoughts and ideas tangible**

FINAL DESIGN



CHAPTER 7

7.1 Design guidelines
7.2 Needs & wishes UI
7.3 Final concept
7.4 Storyboard
7.5 Value of the design
7.6 Concept evaluation

For the final design, the design takeaways from chapter 5, the haptic principles from chapter 6, and the needs and wishes of UI are taken into account. From the problem introduction and the theory, it was perceived that the design needs to be able to translate between different disciplines as a so-called boundary object. This boundary object can be part of the shared repertoire in UI as a community of practice and social learning system. It will help to share tacit knowledge which can help to explain experiences that the students have gained during their graduation project.

In this chapter, a more detailed description of what the design should entail will be given by providing design guidelines and summarizing the needs and wishes of UI. Furthermore, the design guidelines retrieved from the theory are summarized. Then the final concept design will be presented with a sketch and an explanation of all the different elements. Afterward, the usage of the concept design will be presented in a storyboard. At last, the concept is evaluated using all design takeaways, principles, and needs & wishes that are obtained during this master thesis.

7.1 Design guidelines

The design guidelines are drawn up for the organization Urban Innovation. The final design can also be used in other scenarios or contexts. The generalization of the final design is described in chapter 7.5.

What should the haptic language design do?

The design should enable the students of UI to share their problem statements, the experiences they have gained during their graduation process, and their plans for the future regarding the graduation project. These experiences are about who they have spoken to, how they approached the various components within their projects, and what they would have done differently. It also includes a reflection on how the students have interpreted the U-shaped learning curve, which serves as the backbone of the learning community of UI.

Who is going to use the haptic language design?

The design will be used by students that work on consecutive graduation projects within UI and the management of UI.

When would the haptic language design be used?

The design is used when a new graduate starts with a consecutive project. This is probably at the end of the project of the other graduate from which the new graduate takes over.

How should the haptic language design work?

The design should be able to guide the students and the management through the process of sharing experiential knowledge without an external facilitator. The design should also be able to guide the students and the management in haptic usages since touch is often not consciously noticed and used for communication.

7.2 Needs & Wishes UI

The haptic language design is developed to fit in the context of UI. Therefore, the needs and wishes of UI need to be taken into account. These needs and wishes are:

1. The haptic language design ritualizes the transfer of knowledge and projects between students. Ritualization means an act with meaning in a defining moment, usually, it marks a transition phase (Elma Oosthoek, personal communication, November 23, 2020).
2. The haptic language design needs to be flexible to be used for multiple purposes.
3. The haptic language design helps to preserve useful tacit knowledge in the organization of UI.
4. The haptic language design enables students to share experiential knowledge, especially the process of the students is important to discuss and understand.
5. The haptic language design provides the new students with a head start in the learning process described in the U-shaped learning curve. This learning curve is the foundation of the learning community of UI.
6. The haptic language design fits within the dynamic environment of UI. There will be no set times to use the design to keep new possibilities open.

7.3 Final concept

The final concept design is a toolkit that consists out of two different sets of cubes, the basic set, and the haptic set. These sets can be used together to create compositions that can help the students to explain their thoughts, ideas, and feelings. The design is based on the touch dimensions texture, weight, and size. Temperature comes back a little in the different textures that are used. Shape is left out because that dimension was often used for how it looked instead of it felt. Without shape, there is more focus on the haptic elements and the design in total becomes more abstract. This abstraction can help the participants to reach a more abstract way of communication that enables them to easier express tacit knowledge. Furthermore, the design contains a guide with exercises that provide structure for what should be discussed and warming-up exercise cards that should be used to get to know each other, and the haptic language design. At last, an instruction sheet is provided that explains the different elements and how they can be used and explains some tips and tricks to get the most out of the session with the concept design.

7.3.1 Elements

The elements consist out of two sets, the basic set, and the haptic set. These sets can be used in combination with the instructions that are provided but can also be used for other purposes because there is no meaning ascribed to them.

Basic elements

The basic elements consist out of wooden cubes in three different sizes with different weights. There is one big cube of 12x12x12cm, four medium cubes of 6x6x6cm, and sixteen smaller cubes of 3x3x3cm. The weights make sure that people need to pick it up to feel it. The weight is added to the cubes by adding lead inside. Because smaller blocks are made heavier than bigger blocks, some will come as a surprise, which will stimulate the participants to feel and compare different cubes. This will make the participants conscious of their touch experiences.

Haptic elements

The haptic elements also consist out of wooden cubes in three different sizes, with six different materials on the six planes of the cubes. There is one big cube of 12x12x12cm, four medium cubes of 6x6x6cm, and sixteen smaller cubes of 3x3x3cm. The materials are selected from 10 categories that are retrieved from the paper of Bergmann, Tiest & Kappers (2006) and can be found in Figure 39. The categories are as equally as possible divided over the different cubes. Because all textures come back multiple times, it is possible to create patterns. This is based on one of the 7 habits of the mind for transdisciplinary learning, patterning.

With six different sides on each cube, the participants are not able to see all the sides in a blink of an eye and need to touch and move them to get an idea

Figure 38. A snapshot of the final design concept MIMIC

of the whole cube. Therefore, the haptic elements trigger the participants to touch it and enable them to experience different touch experiences. Furthermore, it will make the participants more conscious of their touch experiences because they need to choose how to place the cube in the composition. Which texture comes on top, which texture is left out, and which texture faces the other participants.

Materials

Figure 39.Material categories used in MIMIC

7.3.2 Warming-up exercises

To help the participants to get acquainted with each other and the usage of the haptic design, different warming-up exercises are developed, see Figure 40 for an example. The warming-up exercises can be divided into two categories, yellow for the exercises to get to know each other, and pink for the exercises that help to get to know the haptic design. Furthermore, the participants must carry out at least one individual assignment and one group assignment that can be recognized by the icon on the card. Because of the variation of the exercises, the warming-up exercises stay interesting for the users. Furthermore, the warming-up exercises could be used as energizers or ice-breakers at other moments within UI. All warming-up exercises can be found in Appendix I.

A tool that is used with the warming-up exercises is a small box with cards that contain random nouns. These cards are used within a couple of warming-up exercises to help users to get a better understanding of all the possibilities the haptic language design has to offer.

7.3.3 Guide

The guide is made for UI and contains exercises that help the students and the management to share their knowledge and discuss relevant subjects for the transition of (graduation) projects, see Figure 41. It makes the design a stand-alone design that can be used without a facilitator.

Before the start of the exercises, it is advised to execute a couple of warming-up exercises. The exercises in the guide are divided into three main subjects. The first exercises are based on the problem statements of the students to see where they overlap and where they can learn from each other. After the problem statements are clear, the process of the former graduate concerning the U-shaped learning curve will be discussed. The last subject is the plan of the new graduate on how to tackle his project also related to the U-shaped learning curve. The guide can be found in Appendix J.

7.3.4 Instruction sheet

The instruction sheet contains an overview of all the elements that are in the box of MIMIC with a short explanation. Furthermore, on the back, there is a list of tips and tricks to help the participants get the most out of their usage of MIMIC. These tips and tricks provide instructions for haptic usage and guidance for abstract usage. It also expresses the importance of sharing personal experiences, which is important in the context of UI. At last, it provides ideas of how the tool can be used in different ways in the context of UI. The instruction sheet can be found in Appendix K.

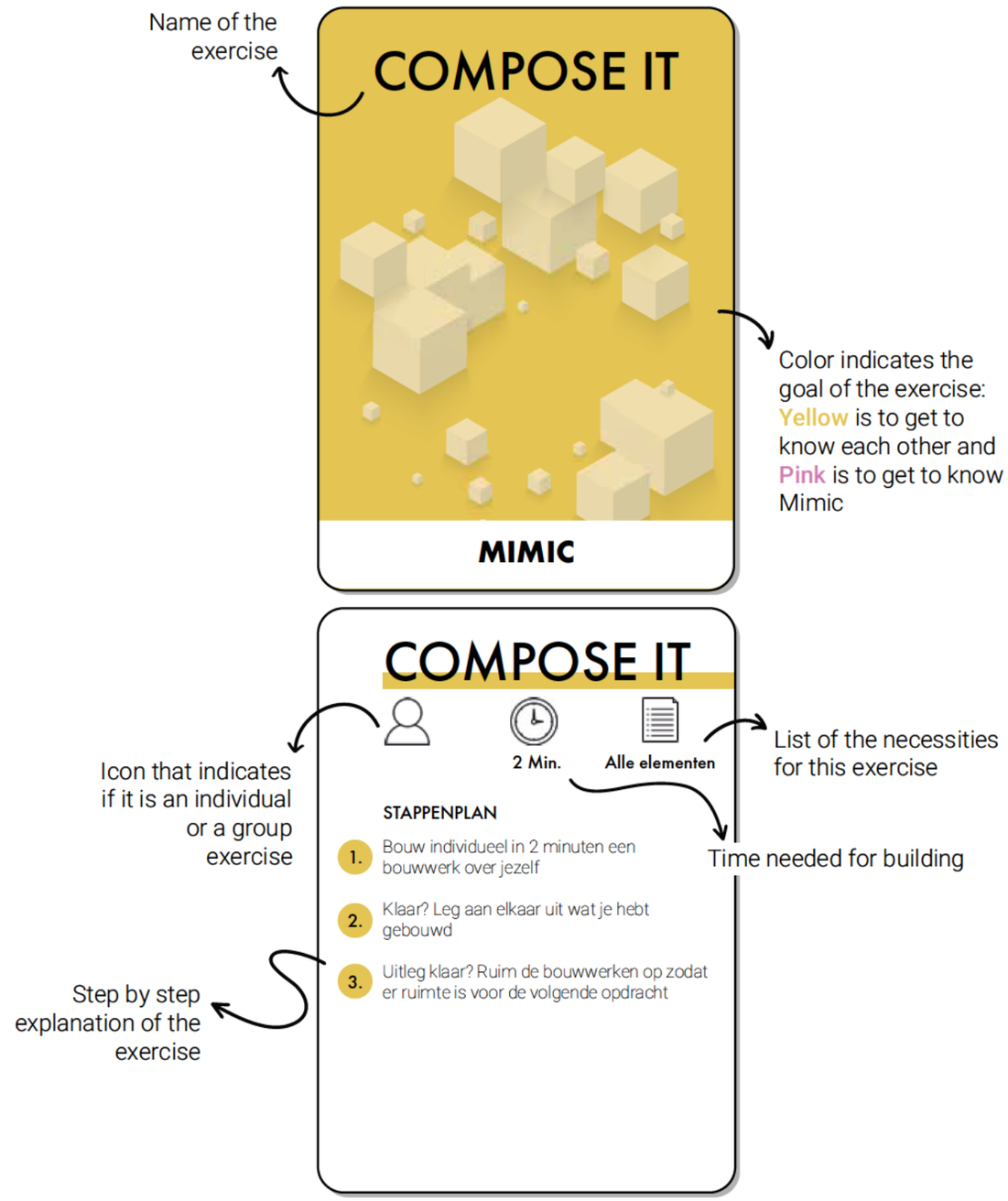


Figure 40.Example of warming-up exercise card

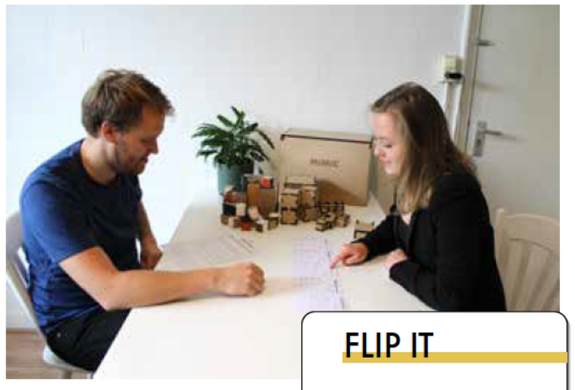
7.5 Storyboard

To show how MIMIC works for UI, but also to show all the possibilities in usage with MIMIC, a storyboard has been created. The storyboard shows a session between a former graduate student of UI called Eva and a new graduate student of UI called Mark. They will follow the instructions that are provided for UI.

1. Eva and Marc meet to discuss their graduation projects with Mimic. Eva just finished her graduation and Marc just started his graduation and will continue with the same topic as Eva.

2. Marc takes the instruction sheet from the box and starts to read what they should do. Eva already feels some of the elements in the box.

3. The first step is to unpack the box, so all the elements are placed on the table. Eva is surprised by the weight of one of the elements and hands it over to Marc to feel the weight.



4. The next step is to choose a warming-up exercise to get to know each other. The first exercise they choose is Flip it to get to know each other.


FLIP IT

Haptische elementen

STAPPENPLAN

1. Kies allemaal individueel ŽŽn haptisch element
2. Met behulp van dit element gaan jullie vragen beantwoorden door de textuur die de vraag het beste beantwoord naar boven te plaatsen. V **oorbeeld**: *ÔHoe gaat het met je?Õ plaatst schuurpapier naar boven. Ôik zit vast met mijn project, het schuurtÕ*
3. Nadat iedereen zijn haptische element heeft geflipt, leggen jullie aan elkaar je antwoord uit
4. De vragen voor deze opdracht verzinnen jullie zelf. Zorg ervoor dat iedereen minstens ŽŽn vraag stelt met als doel elkaar te leren kennen
5. Alle vragen gesteld en beantwoord? Ruim de haptische elementen weer op

5. For this exercise Marc and Eva both choose one haptic element to answer some questions. Jolien asks the first question: "*How are we today?*"

6. When Marc and Eva both have chosen a material Marc explains his answer: "*I have chosen this soft fabric, because I feel sleepy*". Eva follows with her explanation: "*I have chosen the little tiles, because I feel a bit clumsy and have stumbled on the sidewalk today.*" They continue with asking each other some other questions.

7. When they are done with Flip it, they choose another warming-up exercise to get to know Mimic. The exercise they choose is Stack it, which is also a group exercise.


STACK IT

1 Min. Alle elementen + kaartendoosje

STAPPENPLAN

1. Bouw in 1 minuut met elkaar een bouwwerk dat niets voorstelt
2. Klaar? Trek nu allemaal individueel ŽŽn kaartje uit het kaartendoosje
3. Neem de tijd om individueel te bedenken hoe het bouwwerk hetgeen representeert wat op het kaartje staat
4. Leg ŽŽnvoor ŽŽn aan elkaar uit wat jullie bouwwerk voorstelt: *Het bouwwerk is een , omdat*
5. Uitleg klaar? Ruim de bouwwerken op zodat er ruimte is voor de volgende opdracht

8. For this exercise they need to build a random construction together in one minute. When Eva has set the timer, they quickly start building.

9. After the timer goes off, they both pick a card with a word from the little box and take the time to think how the construction represents the word on the card.

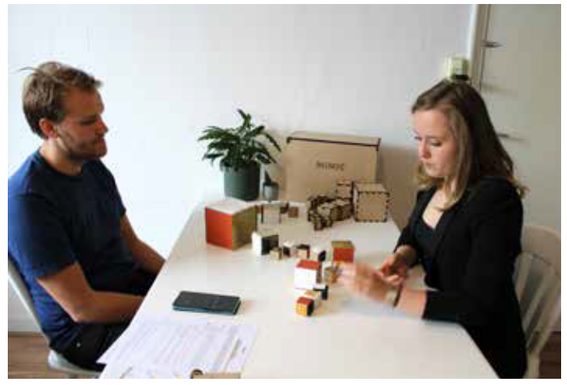
10. They both explain what the construction represents according to their drawn cards.

11. After the second warming-up exercise, they decide that they have an idea of how they can use Mimic. They clean the table for the next exercise and continue reading on the instruction sheet.

12. The first exercises are about the problem statements of their graduation projects. First the have to individually build their problem statements in 3 minutes. Marc starts the timer and they both start building

13. When the problem statements are build, Eva starts to explain her problem statement with the help of the construction. Marc asks questions and changes one of the haptic elements in her construction by putting a different material on top. This makes Eva rethink what she was explaining and gives her an extra reflection moment.

14. Then Marc explains his problem statement with the help of his construction. Eva asks questions and adds an element to the construction to challenge Marc to see his problem statement in a different way. When the problem statements are clear, they discuss the similarities and differences between the problem statements.



15. The next couple of exercises are about the process of the former graduate (Eva). The first exercise is Eva to build her process in 1 minute. This will provide a first rough version of her process, that will be refined when she explains her process.

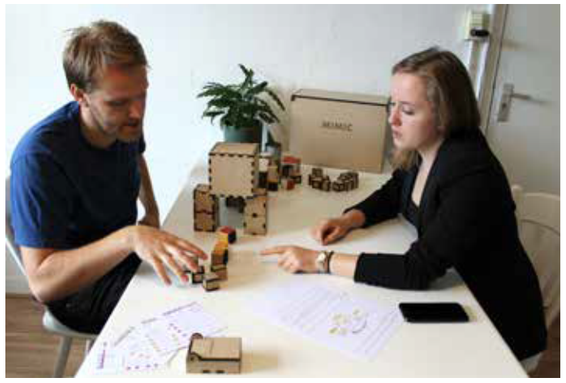
16. After Eva has explained and refined her process, she lets Marc experience it, by guiding his finger over the materials while he is blindsided. This helps Eva to explain her process better.

17. After Marc has felt and understood the process, he challenges Eva with a couple of comparing exercises to get a deeper understanding of her process. He asks her: "*I did not hear you about interviewing the residents in your process, so if you compare these two materials, with which material would you describe this step?*"

18. When Eva and Marc feel the construction of the process is complete, they continue with discussing the ups and downs and how Eva applied the learning curve of UI in her project.

19. After they feel they have discussed everything about the process of Eva's graduation, they clean the table and are ready for the last couple of exercises about the future plans of Marc's graduation project.

20. The first exercise is for Marc to build the process as he imagines it in 1 minute. This provides a rough first version that can be refined when he explains and discusses it with Eva.



21. Marc explains his plans while Eva gives advice about how to tackle problems he foresees. They also discuss how Marc can apply the learning curve in his process.

22. When they feel they have discussed everything about the plans of Marc, they are finished and put everything back in the box. They leave with new insights and knowledge.

7.5 Value of MIMIC

Although MIMIC was initially designed to fit the context and problem of Urban Innovation, it can be used in multiple different situations. As already stated briefly in the first chapter of this master thesis, in general, the case of UI describes a transdisciplinary learning context whereby people from different disciplines interact and learn with each other. Coming from different disciplines means people possess different knowledge that they want to share to create a common understanding. The sharing of this knowledge can be complicated if one only has words to describe it. Therefore, MIMIC provides value in allowing users to express themselves differently and making thoughts and ideas tangible for others to see and feel. This different way of expressing knowledge you possess as a person will make it easier to share tacit knowledge, the knowledge that we find hard to express in words. Also, a different way of expressing yourself can bring new insights, because you often take a different perspective on the subject.

In essence, MIMIC provides value in situations whereby people with different ideas, different backgrounds, or different knowledge want to collaborate and therefore feel they need to understand each other and words cannot provide this understanding. Therefore, MIMIC can help to bridge. This can also be useful during meetings or discussions. MIMIC does not have a long set-up time, but can immediately be used, just like scribbling something on paper.

Furthermore, the warming-up exercises can be used as icebreakers in all situations whereby new collaborations are happening and could also be interesting to use during creative sessions. In these situations, exercises like the warming-up exercises could also be used as an energizer or to get into a creative mindset, because it can help users to get different perspectives.

7.6 Concept evaluation

At last, the design is validated by looking into how the design fits with the design takeaways of chapter 5, the haptic design principles of chapter 6, and the needs & wishes of UI in chapter 7.

		How is this implemented in the final concept design?
Prototype design takeaways (chapter 5)	Clear instructions for haptic usage	Instructions for haptic usage are given in the instruction sheet. Within the warming-up exercises, it is tried to integrate haptic usage in the design itself.
	More focus on the 7 habits of the mind	• By making sure that all textures are equally apparent in the design, it is possible to create and recognize patterns. Also, an exercise is created to look for similarities and differ-ences. (patterning) • By making all the elements one shape, namely cubes, it will be harder to build literally and therefore the users are forced to take a more abstract approach to build. (abstracting) • Within the instructions that are provided, it is tried to let the users fo-cus on how they experience to touch and to let them experience a bit of each other's process of gradu-ation. (embodied thinking) • With the warming-up exercises, it is tried to create fun exercises that do not have any relation with the tran-sition between the projects. (playing)
	More focus on haptic dimensions	The dimension shape is left out of the design because this dimension is more used for its looks compared to how it feels. Furthermore, more attention is given to weight in the basic elements.
	Guidance for abstract usage	Within the instruction sheet, it is written down that users can let each other perform comparing exercises and they are stimulated to ask each other questions. Also, with the warming-up exercise 'Flip it' is tried to fo-cus on how they can use the feeling of materials to express something. How materials feel is often linked to abstract values.
	Stimulation for abstract building	By making all the elements one shape, namely cubes, it will be harder to build literally and therefore the users are forced to take a more abstract approach to build.
	Process of students contains most va-lua-ble knowledge to transfer	It has been made sure that the process of the former graduate has been discussed elaborately. Hereby, discussing the facts, discussing high and low points, and discussing why it that were high and low points from the context mapping method are taken into account to reach the level of tacit knowledge as best as possible.
	Focus on sharing per-sonal experiences	The sharing of personal stories is noted in the tips & tricks that are delivered with the design but is not taken into account when designing the exercises or the warming-up cards.
Haptic design (HD) principles (chapter 6)	HD triggers to touch	By applying different weights that do not align with the sizes, users are stimulated to try out all the basic elements to see which ones are heavier. By applying six different materials to the six different sides of the haptic elements, the elements need to be picked up to be explored fully.

	HD makes people conscious of touch experiences	By applying six different materials to the six different sides of the haptic elements, the elements will feel different every time and therefore can create awareness. Also, the weights that are applied to the basic elements can cause a surprise reaction when one of the blocks appears to be very heavy. This surprise will make the user more aware of how the elements feel compared to each other.
	HD enables different touch experiences	By applying materials from 10 different categories that have their own haptic perception, different touch experiences are created. By also making sure not one haptic element is the same, every time a haptic element is picked up, it can feel different because different materials are touched at the same time.
	HD translates and ad-justs between disci-plines	The tool contains all kinds of different materials and weights, but these are not given any meaning. It is up to the users to create the meaning of the elements.
	HD evokes interaction	By creating modular elements, the tool can be easily used to create compositions together. The warming-up exercises contain group exercises to stimulate collaboration and, in the exercises, it is tried to stimulate the users to actively be involved in the building process of other participants. Furthermore, the haptic design does not make sense on its own, it needs the meaning that the user has applied to the elements to make sense, which means the users need to interact to make this meaning clear to one another.
	HD makes the internal world physical	By making it modular and let users give their meaning to the elements, the design makes it possible to make the internal world tangible.
Needs & wishes UI (chapter 7)	The design ritualizes the moment of transition between projects	By creating a session for the transition between projects a moment is marked when the transition is happening. It provides structure to the transition and creates meaning.
	The design can be used for different purposes	Because there is no meaning given to the different elements, the design can be used in all different kinds of situations. For example, it can be used when someone wants to explain an idea or when people want to understand each other's problems better. Furthermore, the warming-up exercises can be used as icebreakers or to get a creative mindset before a brainstorming session.
	The design helps to preserve tacit knowledge	By creating exercises that discuss the relevant topics and take into account the different levels that should enable people to express tacit knowledge from the context mapping method the tool should help to preserve tacit knowledge. However, one can never tell for sure if tacit knowledge is shared and preserved.
	The design helps to share experiential knowledge	By creating exercises that discuss the process of the former graduate and future plans of the new graduate, experiential knowledge will likely be shared. However, more focus could have been on integrating sharing personal experiences within the exercises.
	The design provides students with a head start in the learning process of UI	By creating exercises that discuss the learning process of UI from the perspective of the project of the former graduate and new graduate it is tried to give the new graduate inspiration and confidence to use the learning process of UI from the start of the project.
	The design fits the dynamic environment of UI	Because the design itself has no meaning, it can be used in all different kinds of situations. The warming-up exercises are made general, so they can be used at different moments. Furthermore, the tool can easily be grabbed and used, without a long setup time, which fits a more dynamic environment.

CHAPTER 7

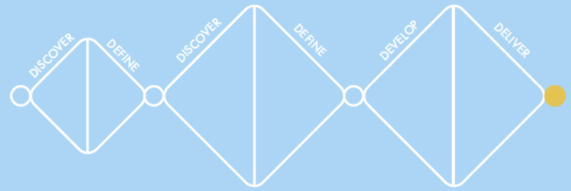
KEY TAKEAWAYS

The final concept design that has been created is MIMIC. MIMIC is a haptic language design that is based on the theory that has been researched and the learnings from exploratory research that are obtained. MIMIC consists out of two sets of cubes, the basic set made of wooden cubes with different weights, and the haptic set of cubes with different materials from 10 categories on each side of the cubes. Furthermore, a guide, an instruction sheet, and warming-up exercises are created to give guidance to the students and the managers of UI for sharing relevant knowledge.

MIMIC can also be used outside the context of UI as a tool to share knowledge, ideas, thoughts, and feelings. With MIMIC the knowledge, ideas, thoughts, and feelings can be made tangible so others can understand them easier. It gives people an extra way to express themselves. Furthermore, it can be used as an icebreaker tool, an energizer or to put people into a creative mindset.

Evaluating MIMIC, most design takeaways, guidelines, and principles are met. Some of them are provided by the extra tips and tricks that are written on the instruction sheet, like haptic usage and sharing personal experiences. It would be more valuable if this could be integrated into the design itself or the exercises provided with the design. That would make the design even stronger.

CONCLUSIONS & DISCUSSION



CHAPTER 8

8.1 Conclusions

This chapter concludes the research performed by answering the research question. The purpose of this thesis was to research if haptics could contribute to communication by developing a haptic language design in the context of Urban Innovation. Each sub-question will be answered by discussing the conclusions. The chapter concludes with answering the main question: "How to improve the transition between graduation projects within the Urban Innovation program of EMI with a haptic language design to preserve knowledge within the different communities of practice."

How can knowledge be transferred between people?
The literature shows that knowledge can be transferred by making it explicit. This can best be done by guiding people in the process of telling stories. By first letting them express the layer of facts, thereafter ask to indicate good and bad and at last, ask why things were good or bad, the layer of needs and values can be reached. It is in this layer that tacit knowledge can be expressed and therefore can be made explicit. Tools can enhance the transfer of knowledge because they can make the internal thoughts, ideas, and feelings tangible. In other words, they can translate between the internal world and the external world of forms. By making it tangible, the knowledge is better understood by others. Furthermore, the 7 habits of the mind, the individual skills that are needed for transdisciplinary learning need to be stimulated to foster learning. Therefore, these habits of the mind should be taken into account when designing tools for the transfer of knowledge between people.

What is 'Haptic design'?
From theory and research, it has been understood that haptic design is based on interactions involving the sense of touch. Physical haptic designs focus on the haptic perception of materials and shapes. They are often used to help blind people make sense of the world. Physical haptic designs should integrate the sense of touch by using the haptic dimensions; shape, texture, hardness, volume, temperature, weight, part motion, specific function, stickiness, and viscosity. To create the most interesting touch experiences, different materials are used. Materials can integrate the dimensions of texture, hardness, temperature, weight, stickiness, and viscosity in the design.

What are the principles for a haptic design that can enhance communication between people?
From theory and research, 6 haptic design principles are created for transdisciplinary learning that can tackle the challenges in designing physical haptic designs for transdisciplinary collaborations. The principles are not hard conditions for these types of designs but should encourage designers to think about how touch can be integrated to stimulate transdisciplinary learning.

The 6 haptic design principles for transdisciplinary learning:

1. Haptic design triggers people to touch it
2. Haptic design makes people conscious of touch
3. Haptic design enables different touch experiences
4. Haptic design translates and adjusts between different disciplines by providing the same meaning for everyone
5. Haptic design evokes interaction between users
6. Haptic design gives people the tools to make their thoughts and ideas tangible

Which knowledge needs to be transferred with the haptic language design for Urban Innovation?
In the context of UI, it has been found that the tacit knowledge that needs to be shared is the experiences the students have gained during the graduation process. These experiences relate to the steps they have taken and what worked well and what did not. By reflecting on the process and the U-shaped learning curve, the experiential knowledge that UI wants to preserve can be made explicit. These learnings they have gathered can help new graduates to get a better connection with the residents and the neighborhood and therefore contribute to a stronger social fabric.

How can haptic design principles be translated into a physical haptic language design?
For each of the 6 haptic principles, there is indicated how they can be translated into a physical design with idea sketches, see chapter 6. Here follows a summary of how each of the principles can be applied in a physical design:

1. Haptic design triggers people to touch it can be applied by using unusual shapes that people find hard to imagine how they feel without touching, by using materials that do not reveal from sight how they feel, or by using touch to control something.
2. Haptic design makes people conscious of touch can be applied by focusing on the dimensions of touch; shape, size, texture, weight, and temperature, or by providing exercises whereby users need to compare elements only based on how it feels.
3. Haptic design enables different touch experiences can be applied by using different shapes or by using different materials to combine different textures, weights, and temperatures.
4. Haptic design translates and adjusts between disciplines by providing the same meaning for everyone can be applied by letting the users create the meaning of the design.
5. Haptic design evokes interaction between users can be done by making it impossible to use on your own or by making it a building kit that they can all use together at the same time to create something.
6. Haptic design gives people the tools to make their thoughts and ideas tangible can be done by making the haptic design modular.

How do graduate students of Urban Innovation experience the use of a haptic language design when discussing their projects?
From the prototype test, it can be concluded that the students and the management of UI were enthusiastic about the use of the haptic language design. They stated it helped them to express themselves and to reach a deeper level of discussion. Students felt inspired and the management of UI felt that it was very helpful to take the time to explore a problem statement of a student in this way because it helps to get a shared understanding of the problem and the future plans of the student regarding tackling the problem.

From the answers to the sub-questions, the following can be concluded about the research question. In the context of UI, it has been found that the transition between graduation projects can be improved by developing a haptic language design that guides the graduate students through their process by sharing personal experiences and reflecting on these experiences. Personal experiences help to share knowledge and make the knowledge better interpretable for others, causing knowledge to be better preserved. Reflecting helps to gain a deeper understanding of the learning process and can lead to new insights and therefore help to create new knowledge.

8.2 Discussion

In this final chapter, the findings of this master thesis about haptics in communication for trans-disciplinary learning are discussed. In this thesis research is performed on how haptics could contribute to the transition between graduation projects within UI to preserve knowledge. From theory, it was retrieved that the haptic language design should enhance transdisciplinary learn-ing. In the following sections, the main findings are explained. It is discussed how they relate to theory and what they mean for haptics in learning communities. Next to that, a critical reflection is given on the theory used in this research. The aim is to get a clear indication of interesting points for further research.

8.2.1 Main findings of haptics in communication

One of the most important results for haptics in communication is that haptic representations are used to explain abstract values, while visual representations are used to explain concrete values. In the prototype test, participants named the feeling of textures to explain 'a smooth beginning' or 'to pamper someone', while the looks of the textures were used to explain 'a golden price' or 'grass'. Therefore, haptics can be used to tell stories on a more abstract level, the level of needs and values. The visual dimensions are used to tell stories on the level of facts. When stories reach the level of needs and values there is the opportunity to share tacit knowledge. By men-tioning how something feels, it is easier for people to ask a question to get a better understand-ing compared to someone building a house with a garden. Questions can help evoke new per-sonal stories that someone wants to share and personal stories can help to trigger other people to also tell their personal experiences.

The second main finding is that personal stories can spark new insights. Personal stories have a snowball effect, whereby one personal story will often evoke other personal stories that partici-pants are eager to share. These personal stories are important for learning because it is in these stories that the experiential knowledge that UI wants to transfer is 'hidden'. It contains knowledge that is not written down. In both sessions of the prototype test personal stories are shared, so the haptic language design helps to share the stories and therefore personal experi-ence. However, the sharing of personal stories is also dependent on other factors, for example how willing participants are to share. If participants are shy and not very talkative, the snowball effect of the sharing of personal stories will be smaller. Therefore, the haptic language design can stimulate the sharing of personal stories, but cannot account for the actual sharing of the stories if people are not willing.

Also, the building of others can spark new insights and create learning opportunities. When other participants actively engage in the building process, they can inspire the participant that is explaining his story. By seeing and hearing the rationale behind the additions made to the com-position the participant can get an idea of how to build further or if he is missing something im-portant for his story. The additions that are made by others also create an extra reflection mo-ment for the participant on the story he is telling. He cannot ignore the additions that are made, but the participant has to form an opinion about it. Therefore, the haptic language design needs to stimulate the engagement of everybody in the building process.

Overall, the building with a haptic language to explain your story is an extra way to get your story across which helps to remember the story better. Repetition is an important aspect of learning because it helps you to remember something better. On top of that, building your story with a haptic language design means expressing your story in spoken word, visual aspects, and touch experiences. You engage three senses, hearing, seeing, and touching, consciously in learning. Engaging multiple senses and experiencing in one story in multiple ways help to create new links in your brain, meaning you are better able to remember the story. From theory, it is known that there are different manners to absorb information, verbal, experiential, and visual (Bradford, 2004). The group of visual absorbers consists of 65% of the population, the group of verbal absorbers is 30% of the population and the experiential learners are 5% of the popula-tion (Bradford, 2004). By using visual aspects, verbal aspects, and touch aspects, almost every-one will be able to absorb the information that is shared. The haptic elements give the partici-pants an extra manner of expressing themselves, which will make it easier to share tacit knowledge.

Also, having a visual and haptic representation of the story on the table makes it easier to keep track of the conversation and therefore increases the level of engagement. It is not easy for peo-ple to listen carefully and be focused the whole time. Furthermore, people get distracted when a question or idea pop's up in their head that they want to share because they try to hold on to this thought and they are not able to listen anymore. The visual and haptic representation on the table can help the participants to keep track of the conversation and can help them to get back to the conversation when their focus slipped away for a moment. It also enables them to quickly build their questions or ideas to park them. When they are out of people's heads, people can listen again and when the other participant finished his story, they will remember their questions or ideas by the quick composition they build.

The last insight is haptic usage is not customary. People tend to use the visual dimensions sooner to represent something, compared to the haptic dimensions. Often choices for certain el-ements are explained by the looks of the elements and only a couple of times by how the ele-ments feel. Therefore, to get more out of the haptic elements, the participants should become aware of how they can use the haptic dimensions. This can be done with guidance in the in-structions of how a haptic language design can be used based on haptic dimensions. Using the haptic language more often can result in haptic dimensions becoming more natural to use as a means of expression. It is like learning a language, the more you practice, the better you will be in expressing yourself in that specific language.

These results indicate that haptics can contribute in the field of communication to share experi-ential knowledge because haptics makes it possible to express abstract values. Furthermore, the haptic language evokes building and the sharing of personal stories that both can evoke new in-sights and ideas. And, haptics in combination with visualizations and spoken word make sure that everybody can absorb information in the way they prefer.

But, the haptic language design on its own is not suitable for transferring experiential knowledge. To transfer knowledge, it first needs to be clear which knowledge people want to transfer. In the context of UI, chosen to make the research more concrete, the goal is to transfer knowledge in consecutive projects to make sure important experiential knowledge stays within the organization. From the prototype test, it became clear that the right questions need to be asked or the right guidance needs to be given to transfer the knowledge. Therefore, one can ar-gue that when the right questions are asked, also another tool, like Lego serious play, could be used. However, the research indicates that haptic elements with a different feel, can deepen the conversation and make it easier to share abstract concepts. Lego serious play for example is on-ly made of plastic and will therefore not help to deepen the communication concerning sharing abstract concepts. Lego serious play also does not offer touch experiences that are an extra way of absorbing the information and remembering it.

8.2.2 Critical reflection on theory

A critical note needs to be made on the theoretical framework concerning Wenger. Most of the theory about social learning systems and communities of practice is based on the ideas of Wenger. It is tried to find other literature about CoP, but almost every source relies on Wenger's ideas. There are hardly any critical reviews written about Wenger's ideas that seemed relevant to mention in this context. Therefore, in the next sections is reflected on Wenger's ideas of CoP.

In the context of UI, it should be discussed if the concept of CoP's as Wenger describes it fits with the goals of UI. The theory of CoP is very complicated in the sense that it contains a lot of elements that need to be taken into account. It is not only about creating tension for social com-petence and personal experience but also involving the three modes of belonging and overcom-ing boundaries. Furthermore, it takes time, effort, and a lot of interactions to make students full-fledged members of a CoP, while they spend only a short time within the organization of UI. Therefore, one can argue that creating a CoP with students is not achievable. The main goal of UI is to create a learning community

whereby knowledge can be shared and preserved and new connections can be created. Therefore, they should focus on creating social interactions, which are also the basis for learning. It is in these encounters that valuable information can be shared that is important to keep in the organization.

If UI still wants to create a CoP, the haptic language design is only one means to create joint ac-tivities and a shared repertoire and is only focused on students and the management of UI. To create a CoP, more joint activities need to be designed and more means for a shared repertoire need to be created. Nowadays, the students rarely interact in joint activities with members of the CoP and also the final concept design does not take other members into account than students and the management of UI. However, the design can be used in interactions with other mem-bers to discuss the problem statement or the process of the student. Furthermore, the design is suitable to be used in other situations, however, no guidance is given for these situations. A shared repertoire of a CoP contains more than one tool, so UI should invest more into tools that can be used throughout the whole organization among all members of the CoP to enable them to learn with and from each other.

As stated, the theory on CoP contains a lot of elements and concepts that need to be taken into account to create a CoP, but even when all elements are present, it does not guarantee that learn-ing takes place. Furthermore, the concepts of social competence and personal experience cannot be influenced by the tool, but the tool can help to make it easier to share them. The tension that according to Wenger is needed between these concepts for learning can also not be influenced by the tool. Creating the right tension, meaning having enough overlap between the students to understand each other, but also enough differences to learn from each other should be done by the managers that decide who to put together. On a bigger scale, it is important to realize that the tool will therefore not work in all contexts and to translate between all people.
Furthermore, the three-step learning cycle of Müller et al. (2005) for transdisciplinary learning is a continuous, iterative process. It takes into account that it takes time to process information and to create your own knowledge out of the things you have observed. This relates to synthe-sizing, the last habit of the 7 habits of the mind, in which an individual tries to combine all that is observed into a whole. Processing all the information that is observed takes time because someone needs to think about it and cannot be done from 1 minute to the other. Therefore, the three-step learning cycle is described over a longer time, not for sessions that have a duration of one hour for example. The session is simply too short to go through the whole three-step learn-ing process and perform the synthesizing step. Learning takes time and repetition. Both con-cepts seemed to be missing in the theory of communities of practice from Wenger.

8.2.3 Relevance and limitations

The research in this thesis is a first step in the research of haptics in communication. Merging haptics into the field of communication to enhance transdisciplinary learning about complex problems is not done before. From VormTaal (Kamp, 2018) is known that an abstract language can be used to make complex problems easier discussable. Still, complexity is hard to make un-derstandable, so new ways to express yourself are interesting to research. Therefore, haptics is chosen to allow people to have an extra form of expression to address complexity. This forms the bridge with transdisciplinary learning, whereby it is important to use all your senses accord-ing to the 7 habits of the mind (Mishra et al., 2011). The results indicate haptics can contribute to making complexity better discussable because haptics can help to explain abstract concepts. This indicates that haptics is also relevant for the broader field of communication.

Haptics fits with the habits of the mind that are necessary for transdisciplinary learning. The 7 habits of the mind indicate that people should use all their senses to gain information, but hap-tics is never consciously used to enhance the habits of the mind.

All the results that are discussed give a first idea of how haptics can be used in the field of communication. Before this master thesis, haptics in communication was an unknown field, and no research on haptics in communication has been performed. Therefore, no literature has been found on haptics in communication. The theory that is used in this research is the theory on haptics in general and how haptics is applied for visually impaired people. The literature on hap-tics in digital technologies, which is an upcoming field in haptic design, is not explored for this master thesis, because the focus was on a physical haptic design. The literature research and haptics in communication could be extended to the digital field.

Another limitation of this research is that all of the tests had only a small number of participants and only represented students from the TU Delft or people that relate to the context of UI. Therefore, the results of this master thesis cannot be generalized. Also, all data has been inter-preted by only one researcher. There was no time to incorporate others in the interpretation of the data. This could have resulted in biased outcomes. To broaden the viability of the analyses, it should be carried out by multiple researchers and designers to justify the choices that formed the basis of the final concept design.

In the prototype test, it has become clear that there are a lot of factors that influence the use of a haptic language design. Not only other senses but also the chemistry between participants plays an important role. In the second session, both participants were less talkative of their own, compared to the two participants from the first session that love to talk with others. Also, the two managers of UI differ in their roles during the session. The manager of the first session is also a haptonome, so she is already concerned with how people feel in certain situations. She was therefore asking questions that are more based on feelings, compared to the manager of the second session that is very practical. This indicates that a lot of factors that influence the haptic language design are not taken into account, but are interesting for further research. This could help to indicate how the haptic language design can contribute to the field of communication when other factors are accounted for.

Another limitation is that due to time restrictions, the six principles that are established have not been validated. Therefore, it cannot be sad with certainty that the ideas of how the principles can be implemented in a design will work. Some of the ideas related to the principles are contradic-tory, for example, use sight to trigger touch, but also eliminate sight to make people conscious of touch experiences. With further research and testing the ideas of how the principles can be applied, it can be found which ideas help to integrate the principles in the design and contradic-tions can be fully eliminated. Because no validation has been done, it cannot be said with cer-tainty that integrating the principles will evoke transdisciplinary learning. The principles should be used as guidelines and a source of inspiration for future haptic designers and communication professionals. The principles are not facts neither requirements.

Also, due to time restrictions, the final concept design has not been validated. Therefore, it can-not be said with certainty that this design works as it was conceived. However, with the data analysis of the prototype design, it can be said with some certainty that the design will work in the context of UI to share and persevere knowledge. For UI, the usage of the final design must be monitored and reflected on, to make sure the design does what it needs to do and to improve the usage and make it a solid part of their learning community. It will provide UI with a first shared repertoire and can set an example for shared activities within the CoP.

Also, the effects of using the haptic language in the transfer of projects of UI compared to the old situations should be measured to see if the haptic language design also establishes learning for the longer term and experiential knowledge stays within the organization.

From a personal perspective, I see haptics as a way to stimulate people to think more out of the box, to see a problem from a different perspective, and to have another option in expressing themselves. Haptics also stimulates to learn together. I think haptics is valuable as a means of brainstorming and getting people out of their comfort zone and sparking new ideas. Therefore, it would be interesting to research if haptics can be useful for brainstorming, just like pictures or random objects are sometimes used to keep the creativity flowing in creative sessions.

This master thesis is a stepping stone for researching haptic design in the field of communica-tion. The study indicates that haptics can contribute to transdisciplinary learning, so it is interest-ing to further research how exactly this can be done. The first indication of principles is given and further research can test these principles to see if they hold. By testing and validating the design within UI, but also in other contexts, can reveal if the design can be generalized and used for different purposes. This research should inspire both designers and communication profes-sionals to start actively involving the sense of touch in their designs and communications.

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APPENDICES

Appendix A

Survey EMI Graduates

6 Participants

Algemeen

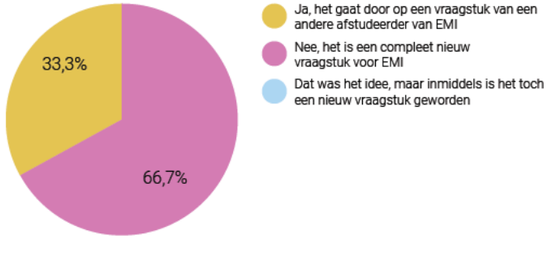
Wat is het vraagstuk waar je aan werkt in één zin:

- Steegbeleving
- Nog niet helemaal duidelijk..
- Op speelse wijze werken aan het waterbewustzijn van de jeugd in Hillesluis
- Hoe kunnen we het weggooigedrag van de bewoners, ondernemers en bezoekers van de wijk Hillesluis beïnvloeden door middel van een (digitale) interventie welke hierbij positief bijdraagt aan de leefbaarheid en veerkracht van de wijk.
- Korte termijn verduurzaming van sociale huurwoningen van Woonstad in de wijk Hillesluis
- Duurzaam ondernemen met oog op culturele sensitiviteit

Hoe ben je aan je vraagstuk gekomen bij EMI?

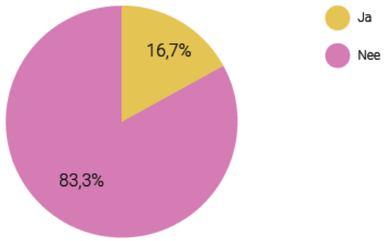
- Overgenomen van Aida
- Vanuit EMI een vraagstuk gekregen maar ik ben nu bezig om deze te herschrijven
- Ik heb de vrijheid gekregen om vanuit mijn eigen fascinatie en achtergrond een onderzoeksvraag te verzinnen
- Het was geen bestaand vraagstuk. Het vraagstuk is deels gekomen door mijn eigen (woon) frustratie als bewoner van de wijk. Tijdens mijn sollicitatiegesprek hebben we hiervoor de mogelijkheden verkend en besloten dat dit een interessante onderzoeksvraag zou kunnen zijn.
- Via een docent in contact gekomen met EMI die benaderd waren door Woonstad
- Door middel van een gesprek over mijn interesse en de liggende vraagstukken bij EMI.

Is het vraagstuk waar je mee bezig bent een vervolg op een vraagstuk waar een andere (oud-)afstudeerder aan heeft gewerkt?

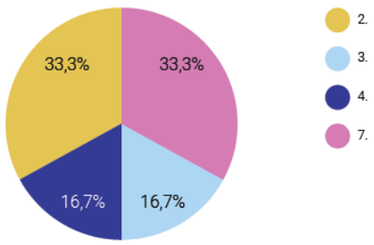


Stakeholders

Heb je al contact gehad met stakeholders die van belang zijn in jouw afstudeerproject?



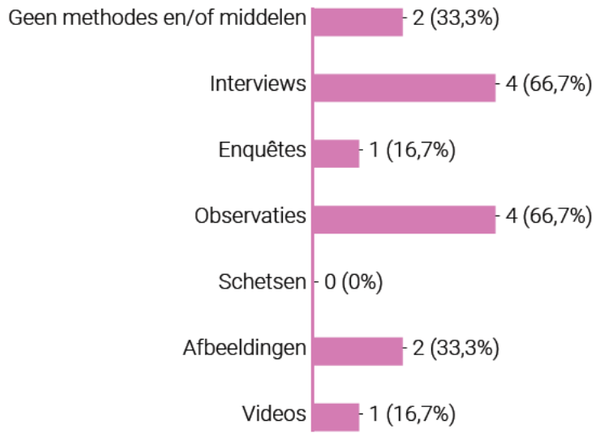
Met hoeveel stakeholders heb je al contact gehad tijdens je afstuderen tot nu toe?



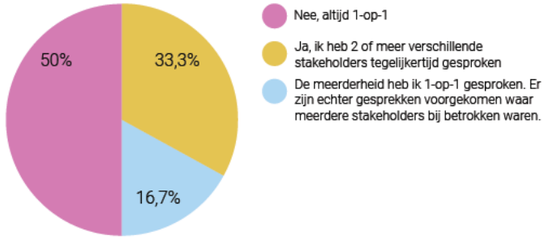
Wat was het doel van het contact met deze stakeholders? Als het verschillende doelen betrof, graag deze allemaal benoemen.

- Een afspraak maken om de probleemstelling vast te stellen
- 1. Expert interviews welke mij zsm op de hoogte konden brengen van ontwikkelingen
  2. Achterhalen waardes van bewoners
  3. Achterhalen afval beleving bewoners
  4. Achterhalen motivatie/drijfveren achterhalen bewoners
  5. Achterhalen 'afval journey' van bewoners
  6. Achterhalen waardes van ondernemers
  7. Achterhalen beleving ondernemers
  8. Achterhalen motivatie/drijfveren achterhalen ondernemers
  9. Achterhalen 'afval journey' van ondernemers
  Ik ben waarschijnlijk tientallen dingen vergeten, maar dit zijn de belangrijkste.
- Om inzicht te krijgen in de doelgroep. Vooronderzoek.
- Bewoners, ik doe het met hen samen. Stadsmarinier Sana, voor informatie en waar zij mee bezig is in het proces.
- Informatie verkrijgen, samenwerking in gang zetten
- Praktische informatie om aan te tonen of theorie aansluit op praktijk en inzicht in maatregelen van andere corporaties

Welke methodes en/of middelen heb je gebruikt in het contact met deze stakeholders?



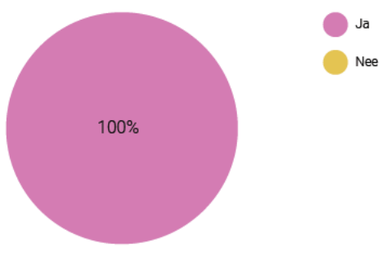
Heb je meerdere stakeholders tegelijkertijd gesproken?



Waarom heb je stakeholders wel of niet samen gesproken?

- Alleen gesproken omdat het vooral over observatie en kennismaking ging, dit geeft een persoonlijkere aandacht.
- In een ideale wereld zou ik alle stakeholders tegelijkertijd met elkaar in gesprek willen gaan, om zo te samen te kunnen co-creëren. Echter is me dat nog niet gelukt.
- Makkelijker samen
- Het was een bewoners bijeenkomst, aankomende vrijdag heb ik telefonische gesprekken ingepland en wil ik als vervolg interviews gaan houden.
- Tot nu toe heb ik enkel via email contact gehad
- Geeft me meer de tijd om goed voor te bereiden en sommige vragen eventueel aan te passen naar de situatie van desbetreffende stakeholder

Heb je nog contactmomenten met stakeholders op de planning te staan?



Wat is het doel van deze aankomende contactmomenten met de stakeholders?

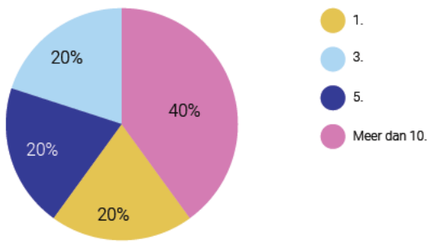
- Vanmiddag met Nico Sizoo van de gemeente Rotterdam
- Vraagstuk helder te krijgen
- Informatie in te winnen, hun kijk te vangen en te pijlen of mijn interview vragen relevant zijn.
- Samenwerking in gang zetten om uiteindelijk met een groep-8 klas te gaan ontwerpen, Interviews houden
- Uitbreiding interview en bezoeken op bouwlocaties

Doelgroep

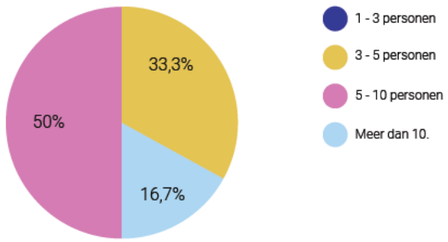
Wie is de doelgroep van je afstudeerproject?

- Nog onbepaald
- De bewoners, ondernemers en bezoekers van de wijk Hillesluis, dit is natuurlijk erg breed. De afvalcontainers staan echter in de publieke ruimte. En moet dus toegankelijk zijn voor ieder.
- Kinderen die wonen in het Stulemeijercomplex
- Bewoners van Riederlaan
- Verschillende overheden, basisschoolleerlingen
- Sociale huurders

Hoeveel personen uit deze doelgroep heb je al gesproken?



Hoeveel personen uit deze doelgroep heb je al gesproken?

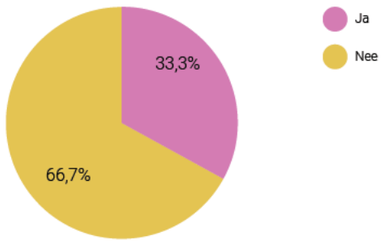


Wat is het doel voor het spreken met de doelgroep? (Kunnen ook meerdere doelen zijn)

- Inzichten vergaren
- Op ideeen te komen
- Is al genoemd, als toevoeging heb ik het inwinnen van informatie wat betreft sturing van mijn vraagstuk en beroepsproduct.
- Algemene informatie verkrijgen
- Achterhalen met welke problemen zij kampen en daarmee een selectie van te nemen maatregelen voor Woonstad op te stellen

Oud-afstudeerders EMI

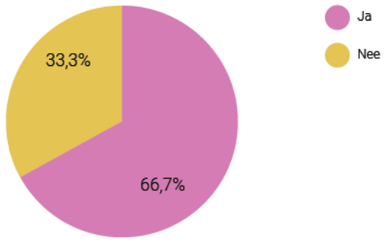
Heb je voor je afstuderen contact gehad met (oud-) afstudeerders van EMI?



Met welk doel heb je (oud-)afstudeerders van EMI gesproken voor je afstuderen?

- Verwachtingen schetsen en voorbeeld
- Informatie verzamelen en het vormen van mijn vraagstuk.
- Nvt

Heb je tijdens je afstuderen contact gehad met (oud-) afstudeerders van EMI?



Met welk doel heb je (oud-)afstudeerders van EMI gesproken tijdens je afstuderen?

- Verwachtingen schetsen en voorbeeld
- Goedkeuring gevraagd voor het inzien van Aida haar scriptie en contacten aangevraagd
- Kijken of er aansluiting te vinden is bij andere afstudeeropdrachten
- Tips aangaande te gebruiken bronnen

Appendix B

Test 1 - Set-up

Benodigdheden:

- Materialen
- Case omschrijving
- Blinddoek
- Telefoon (Camera + Geluidopname)

Test 1 bestaat uit een individuele test van 3 stappen om te kijken of het bewust voelen van materialen ervoor zorgt dat men op een andere manier informatie gaat overbrengen.

Denk aan:

- Vragen of je het mag filmen
- Tijd bepalen voor test, hoe lang elk materiaal zien en/of voelen

Hypotheses

1. Het voelen van materialen zorgt voor andere associaties dan het alleen zien van materialen.
2. Het zien en voelen van materialen zorgt voor een uitgebreidere omschrijving van het materiaal.
3. Het zien en voelen van materialen zorgt voor meer associaties t.o.v. alleen zien of alleen voelen.
4. Het voelen van materialen maakt het makkelijker om een gevoel te hebben bij een materiaal.
5. Alleen zien of alleen voelen zorgt voor verschillende gevoelens en emoties bij het materiaal.
6. Zien en voelen levert een combinatie op van de verschillende gevoelens en emoties die genoemd worden bij alleen zien en alleen voelen.
7. Deelnemers die de materialen hebben gevoeld gebruiken de materialen als voorbeeld om aan te geven wat ze voelen bij het lezen van de case, het voelt net als materiaal x, want ..
8. Het voelen van materialen zorgt voor het gebruik van meer bijvoeglijk naamwoorden

Stap 1. – Kijken, Kijken & Voelen, Voelen

In de eerste stap zullen de drie verschillende groepen de materialen verkennen en daarover vragen beantwoorden. De materialen zullen 1 voor 1 worden gepresenteerd en per materiaal zullen dezelfde vragen worden gesteld aan elke deelnemer. De materialen zullen steeds in dezelfde volgorde worden gepresenteerd. De manier waarop de deelnemers de materialen verkennen zal verschillen per groep:

- Groep 1 – Kijken
  Deze groep zal de materialen zien op tafel, maar zal ze niet aanraken. Puur op basis van visuele aspecten zullen zij de materialen verkennen.
- Groep 2 – Kijken & Voelen
  Deze groep zal de materialen zien op tafel en wordt gevraagd deze aan te raken en te voelen. Op basis van visuele en haptische aspecten zullen zij de materialen verkennen.
- Groep 3 - Voelen
  Deze groep zal de materialen niet zien (geblinddoekt), maar wordt gevraagd deze wel aan te raken en te voelen. Puur op basis van haptische aspecten zullen zij de materialen verkennen.

Vragen per materiaal

1. Kan je omschrijven wat je ziet en/of voelt?
2. Waar doet het materiaal je aan denken?
3. Welke associaties krijg je bij dit materiaal?
4. Welk gevoel krijg je bij dit materiaal?

Vragen over alle materialen

1. Welk materiaal vond je het prettigst om te zien en/of voelen? En Waarom?
2. Welk materiaal vond je het minst prettig om te zien en/of voelen? En Waarom?

Stap 2. – Case lezen

In de tweede stap van de test krijgen de deelnemers een a4-tje waarin kort het probleem van jongerencriminaliteit wordt uitgelicht met name in de wijk Charlois. Aan de deelnemers wordt gevraagd dit door te lezen.

Stap 3. – Kennis overdragen

Nadat ze de case hebben gelezen, worden er vragen gesteld om te zien hoe ze de informatie in de tekst vertalen naar iemand anders in woord.

Je hebt deze informatie gekregen en gelezen. Het idee is dat je deze informatie met mij gaat delen, alleen krijg ik het niet te lezen. Je zult dus de informatie die jij tot je beschikking hebt aan mij moeten overdragen door het aan mij te vertellen. Je moet ervanuit gaan dat ik nog nergens van af weet. De informatie hoeft niet correct te zijn, maar het is belangrijk dat je het om zet in je eigen woorden.

1. Kan je mij kort uitleggen wat het probleem is?
2. Wie denk jij dat de belangrijkste stakeholders zijn in dit probleem?
   a. Waarom zijn deze stakeholders het belangrijkst?
3. Wat zijn je eerste ideeën voor het oplossen van dit probleem?
4. Wat voor gevoel krijg je bij het lezen van deze case?
   a. Waarom roept deze case dat gevoel op?

Appendix C

Test 2 - Set-up

Goal

The goal of this test is to see if and how textures, one of the dimensions of haptics, can influence the communication between people when analyzing and building a complex social problem.

Hypotheses

1. Groups of people that have textures at their disposal will first explore the blocks by touching and feeling them, while the group with no textures has no interest in touching and feeling the blocks before working with them. So, the textures invite to explore the blocks.
2. The groups that have textures at their disposal will use these textures to talk about the case, they will explain their thoughts by using the feeling of the texture, e.g., a smooth texture can be used to explain that there is smooth communication between two involved stakeholders, while a rough texture can be used to explain a communication that falters.
3. The groups that have textures at their disposal find it easier to use the building blocks because they have more possibilities in usage. They can not only use the height and length, combine blocks, but they can also use the different textures to indicate different type of relations.
4. The groups that have textures at their disposal will pass blocks around to let other people feel what they mean and to discuss if the other agrees with this texture.
5. The groups that have textures at their disposal will take longer to make decisions about which blocks to use and how to build the complex problem.
6. The groups that have textures at their disposal will have more interaction during the discussions, meaning they will talk more about how to use the blocks and will more often pass blocks around.
7. The groups that have textures at their disposal will attach more and different values to both the blocks in general as well as the textures.

Necessities:

- Building blocks 2 sets: 1. Plain building blocks of wood, 2. Building blocks with textures added
- Case description (2x)
- Camera & tripod
- Timer
- Pen & Paper
- Evaluation forms (2x)

Number of Participants: 12, 3 pairs of 2 people (6 people) in each group.

Set-up

In this test two groups will be compared. The first group will work with a prototype that consists out of wooden building blocks with a smooth surface. The second group will work with a prototype that consists out of the same wooden building blocks but they will have different textures on the outside, all in the same color white.

To get acquainted with the building blocks and how they can be used, the participants will first do two different warm-up exercises that are explained in more detail below.

After the warm-up exercises, both groups will be asked to read a case description that explains a social complex problem in Rotterdam South. They will be asked to read the description and to build the situation with the building blocks. They will have to work together to come to a collective understanding of the problem and a composition on which they all agree. After they have made the composition, both participants will be asked to explain the composition that they have built.

After the explanation of what they have built, they will be asked to fill out an evaluation form to get an idea of how they have experienced the use of the building blocks for analyzing the problem.

Rules:

- They work together in pairs on the same problem
- They have to use the building blocks to come to a collective set-up of the problem
- If they feel information is missing, they can make their own assumptions

Before the start:

- Inform the participants about the recordings that will be made and explain how they will be used in the research
- Ask if the participants want to think out loud
- Explain they have to use the building blocks on the table to analyze the problem and to create a composition of this problem
- Explain that they can use the building blocks in different ways, they can combine forms to create masses or spaces. They can use the building blocks to indicate relationships between different parts of the composition.

Warm-up exercises (15 min):

To get the participants acquainted with the building blocks, two warm-up exercises will be done. This will also help to see the possibilities of how the blocks can be used.

Exercise 1 (7 min)

The first exercise is to build a duck with 5 pieces in 3 min. After the 3 min are over, both participants explain how it is a duck. After the explanation they are asked to remove 2 bricks so they have 3 left and both participants are asked again how it is still a duck.

Exercise 2 (5 min)

The second exercise is to build whatever they feel like in 3 min. After the 3 min are over, I will assign the meaning of “your favorite activity” to the models they have built. The participants are asked to explain how the model represents their favorite activity in 1 min.

Assignment for the participants (30 min):

- First read and analyze the given information
- Second, build a composition that explains the current situation of the case by using the building blocks.

Don’t forget to make pictures of the end-composition!
Write down important observations during the assignment!

Observation (after all tests)

By filming the participants during the test, it is possible to afterwards observe how the participants use the building blocks. During this observation different questions will be asked:

1. In which ways are the participants using the building blocks?
2. What are the values they attach to the forms?
3. What are the values they attach to the textures?
4. Do the values they assign to the forms and textures change during the test?
5. In which ways do the building blocks and textures support the discussion and how does this discussion change with the use of the building blocks and textures?
6. What are the differences between the two groups in use of the blocks, verbal and non-verbal communication?

Test 2 - Evaluation form

Vraag 1. Wat is je eerste indruk van het gebruiken van deze blokken in de discussie over het probleem?

Vraag 2. Was het duidelijk hoe je de blokken kon gebruiken? Ja/Nee

Licht toe...

Vraag 3. Was het duidelijk hoe je de texturen van de blokken kon gebruiken? Ja/Nee

Licht toe...

Laat weten in hoeverre je het eens bent met de volgende stellingen en waarom:

4. De blokken hebben geholpen om het probleem beter te begrijpen:

Helemaal oneens ◯ ◯ ◯ ◯ ◯ Helemaal eens

Licht toe...

5. De blokken helpen in de discussie over het probleem:

Helemaal oneens ◯ ◯ ◯ ◯ ◯ Helemaal eens

Licht toe...

6. De verschillende texturen van de blokken helpen in de discussie over het probleem:

Helemaal oneens ◯ ◯ ◯ ◯ ◯ Helemaal eens

Licht toe...

7. Ik heb gebruik gemaakt van de verschillende mogelijkheden die de blokken bieden in hun gebruik (denk hierbij aan het gebruik van de vorm, lengte, gewicht, grootte etc.):

Helemaal oneens ◯ ◯ ◯ ◯ ◯ Helemaal eens

Licht toe...

8. Ik heb gebruik gemaakt van de verschillende texturen die de blokken hebben:

Helemaal oneens ◯ ◯ ◯ ◯ ◯ Helemaal eens

Licht toe...

Vraag 9. Vind jij dat er genoeg variatie zat in de blokken die je tot je beschikking hebt gekregen en waarom?

Vraag 10. Heb je vormen gemist?

Ja, namelijk:
Nee

Vraag 11. Heb je texturen gemist?

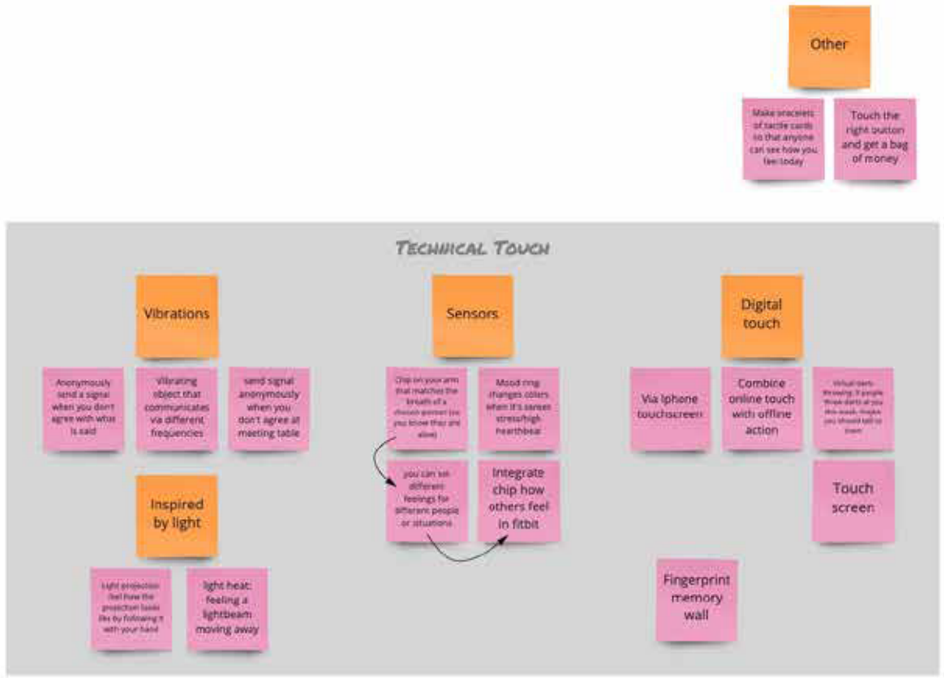
Ja, namelijk:
Nee

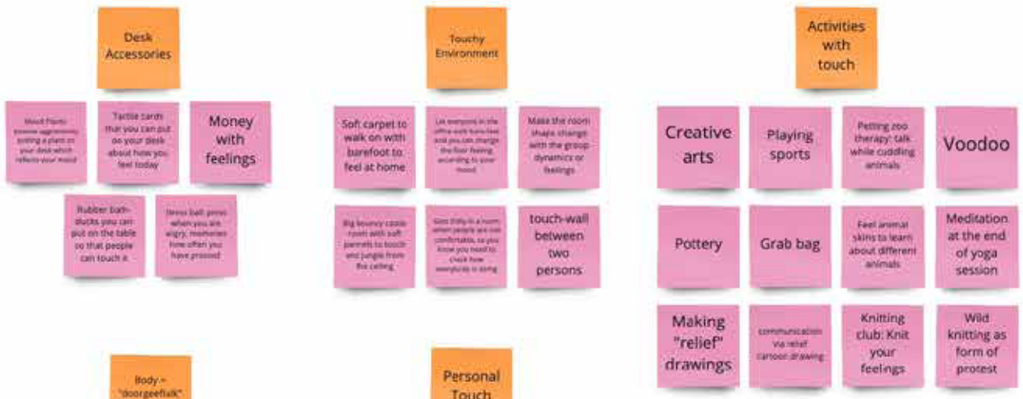
Vraag 12. Heb je nog andere dingen gemist aan de blokkenset, bijvoorbeeld andere dimensies als gewicht en waarom?

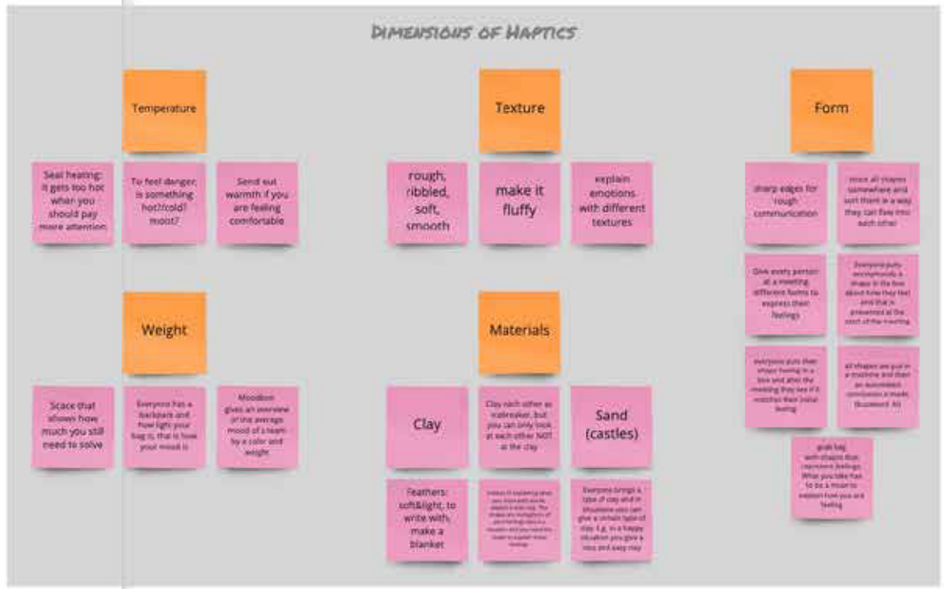
Vraag 13. Heb je nog opmerkingen of tips?

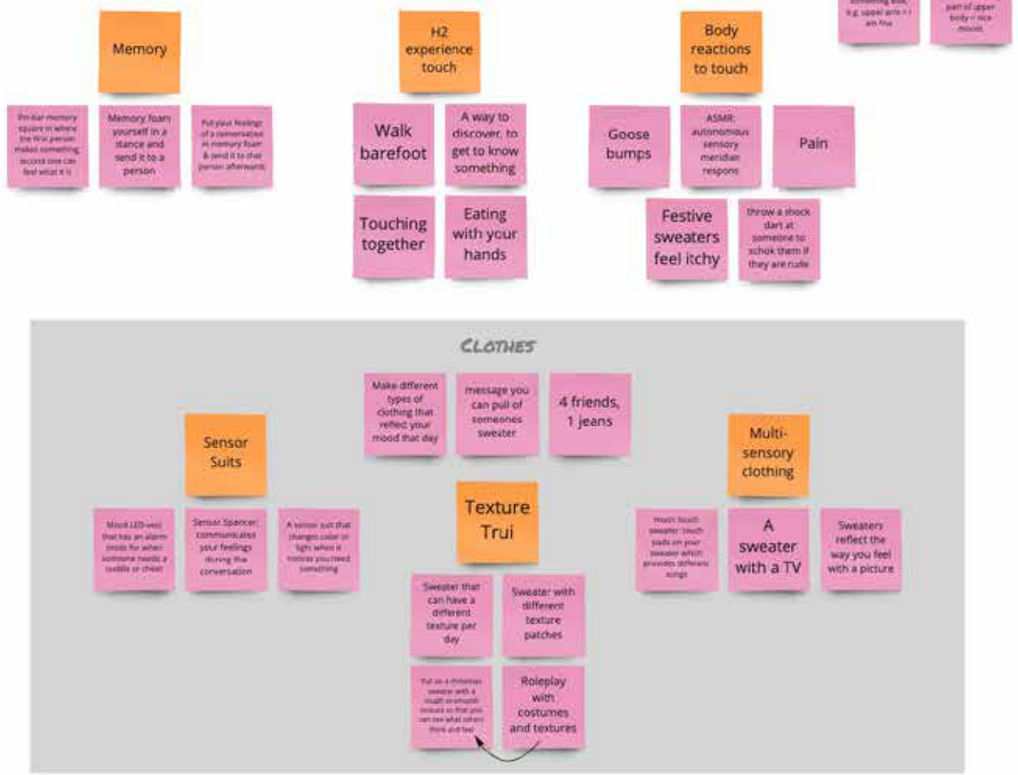
Appendix D

Results pilot brainstorming session



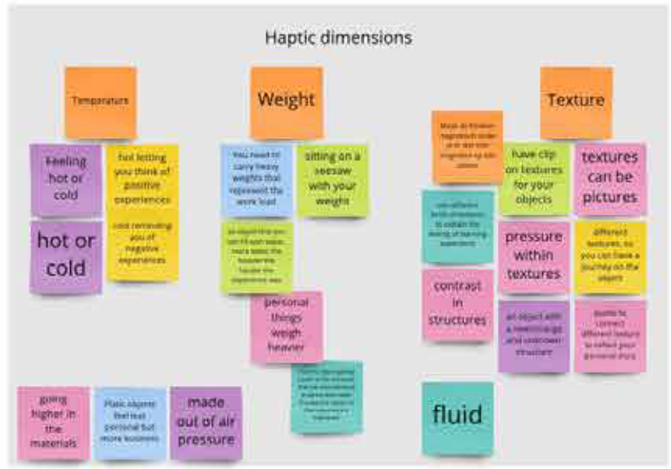


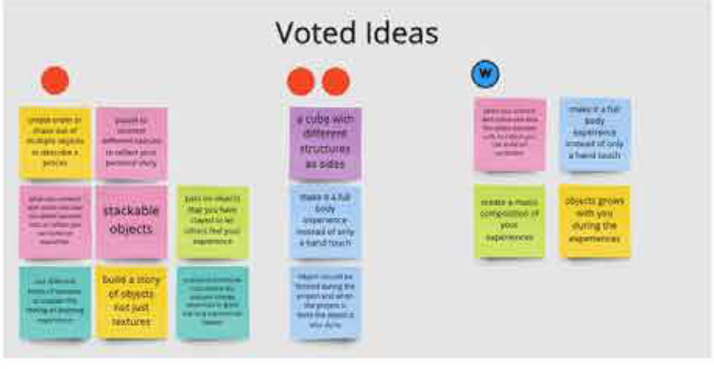




Appendix E

Results brainstorming session





Appendix F

Guide of the prototype

Gids

Warm-up Ronde

Nu jullie de tool hebben uitgepakt en verkent is het tijd om de tool ook echt te gaan gebruiken. De volgende warm-up opdrachten zullen ervoor zorgen dat jullie ontdekken op welke manieren de verschillende materialen te gebruiken zijn.

Werk de drie opdrachten 1 voor 1 af. Bij elke opdracht staat ook aangegeven hoeveel tijd je voor de opdracht moet nemen om te bouwen. Zorg dat iemand een timer instelt op zijn telefoon en hou je aan de tijd!

1.

2 Minuten

In de toolkit bevindt zich een doosje met kleine kaartjes. Laat 1 iemand blind een kaartje uit het doosje trekken en lees het kaartje voor. Bouw nu allemaal **individueel** wat er op het kaartje staat. Aan het einde van het bouwen hebben jullie dus 3 bouwwerken gemaakt. Neem hiervoor 2 minuten.

Klaar? Leg nu aan elkaar uit waarom hetgeen dat je hebt gebouwd, hetgeen is wat op het kaartje staat. (*"Mijn bouwwerk is een .., omdat .. "*)

Leg vervolgens alle materialen die jullie hebben gebruikt terug en ga verder met opdracht 2.

2.

2 Minuten

Bouw nu allemaal **individueel** een bouwwerk over jezelf met de materialen uit de toolkit. Aan het eind van het bouwen hebben jullie dus weer 3 bouwwerken gemaakt.

Klaar? Leg nu aan de hand van je bouwwerk aan elkaar uit wie je bent, zo leren jullie elkaar nog wat beter kennen. (*"In mijn bouwwerk kan je mij terug zien, omdat .."*)

Leg vervolgens alle materialen die jullie hebben gebruikt terug en ga verder met opdracht 3.

3.

2 Minuten

Voor de laatste opdracht bouwen jullie **samen** een random bouwwerk wat geen betekenis heeft, maar wel samen een geheel vormt.

Klaar? Draai dan de pagina om en lees verder. **Maar alleen als het bouwwerk af is en de 2 minuten zijn verstreken.**

Vervolg Warm-up Ronde

3.

Vervolg:

Nu jullie gezamenlijke bouwwerk af is, wordt het tijd om erachter te komen wat jullie hebben gebouwd. Pak nu allemaal blind een kaartje uit het doosje, zodat iedereen een eigen kaartje heeft. Bestudeer nu het kaartje en het bouwwerk. Neem even de tijd om erachter te komen hoe het bouwwerk representeert wat er op het kaartje staat.

Leg nu aan elkaar uit hoe het bouwwerk, hetgeen representeert wat op het kaartje staat. (*"Ons gezamenlijke bouwwerk is een .., omdat .."*)

Goed gedaan, jullie hebben de warming-up voltooid. Leg alle materialen weer terug langs de ondergrond en ga door naar Ronde 1 op de volgende bladzijde.

Ronde 1

Nu jullie een idee hebben gekregen hoe jullie de materialen uit de toolkit kunnen gebruiken is het tijd om door te gaan met opdrachten die jullie meer inzichten kunnen geven in jullie eigen projecten voor Urban Innovation.

De opdrachten in Ronde 1 en Ronde 2 zijn bedoeld om een discussie op gang te brengen en kennis uit te wisselen die van belang kan zijn voor jullie projecten en Urban Innovation als kennisnetwerk. Hierbij zal Ronde 1 gericht zijn op het project van de student dat bijna afgelopen is en Ronde 2 gericht zijn op het project van de student die net is begonnen.

Probeer aan de hand van de materialen de opdrachten uit te voeren en de vragen die worden gesteld te beantwoorden. Om te zorgen dat kennis wordt gedeeld is het blenagrijk om hard op te denken, elkaar vragen te stellen en kritisch te zijn naar elkaar.

1.

10 Minuten

Er is 1 student die aan het einde is van zijn project voor Urban Innovation en 1 student die net is begonnen aan een nieuw project voor Urban Innovation. De opdracht heeft betrekking op **de probleemstelling** van de student die aan het einde is van zijn project.

Probeer met behulp van de materialen de probleemstelling waar je aan hebt gewerkt te bouwen en leg ondertussen uit wat je bouwt.

De anderen deelnemers kunnen helpen bij het bouwen en vragen stellen om de probleemstelling voor iedereen helder te krijgen.

Neem voor deze opdracht 10 minuten en **vergeet niet om een timer te zetten!**

Klaar? Laat je bouwwerk staan en ga verder met opdracht 2.

2.

5 Minuten

Nu de probleemstelling is gebouwd is het tijd om te evalueren of ook alle **stakeholders** zijn meegenomen in het bouwwerk. Voeg stakeholders die belangrijk zijn toe aan het bouwwerk en bespreek waar ze moeten staan ten opzichte van het probleem en ten opzichte van elkaar. Bespreek wat de relaties zijn tussen de stakeholders en wat de relatie van de stakeholder is met het probleem. Neem hiervoor 5 minuten.

Klaar? Laat je bouwwerk staan en ga verder met opdracht 3.

Vervolg Ronde 1

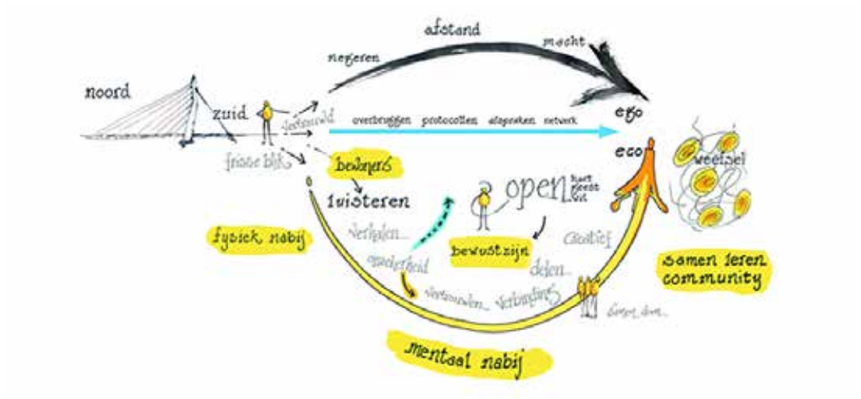
3.

15 Minuten

Als laatste opdracht is het de bedoeling dat de gebouwde probleemstelling wordt omgevormd in **de oplossing** die is bedacht.

Probeer dus vanuit de probleemstelling en de stakeholders duidelijk te maken hoe de oplossing de situatie heeft veranderd en bouw het. Probeer tijdens je uitleg ook te benoemen wat de moeilijkheden waren in het proces om tot deze oplossing te komen. Neem hiervoor **10 minuten** de tijd.

Als dit is gelukt, neem nog **5 minuten** de tijd om te bespreken hoe de leercurve van Urban Innovation terug te zien is in het proces dat je hebt doorlopen van probleemstelling naar oplossing en welke inzichten je daarin hebt opgedaan. Een afbeelding van de leercurve is hieronder te zien.



U-vormige leerbocht, Elma Oosthoek, 2020

Als jullie de eerste drie opdrachten hebben voltooid en geen vragen meer hebben aan elkaar kunnen jullie de materialen weer van de ondergrond af halen en doorgaan naar Ronde 2.

Ronde 2

De opdrachten in deze ronde staan in het teken van het project van de nieuwe student die net is begonnen bij UI.

Vergeet ook bij deze opdrachten niet om hard op te denken, elkaar vragen te stellen en kritisch te zijn. En vergeet niet om een timer te zetten.

1.

10 Minuten

De eerste opdracht heeft betrekking op **de probleemstelling** van de nieuwe student die net is begonnen aan zijn project voor Urban Innovation.

Probeer met behulp van de materialen de probleemstelling waar je aan hebt gewerkt te bouwen en leg ondertussen uit wat je bouwt.

De anderen deelnemers kunnen helpen bij het bouwen en vragen stellen om de probleemstelling voor iedereen helder te krijgen. Probeer antwoord te krijgen op de vraag **hoe de twee problemen met elkaar verbonden zijn**. Wat zijn bijvoorbeeld overeenkomsten en waar zitten juist de verschillen? Neem voor deze opdracht 10 minuten.

Klaar? **Laat je bouwwerk staan** en ga verder met opdracht 2.

2.

10 Minuten

Evalueer ook weer bij dit probleem of alle belangrijke **stakeholders** zijn meegenomen of dat er nog stakeholders moeten worden toegevoegd. Denk ook nu weer aan de verhouding van de stakeholders tot het probleem en de onderlinge relaties tussen de stakeholders. **Neem hiervoor 5 minuten.**

Als alle stakeholders zijn toegevoegd, bespreek dan met elkaar welke contacten nog handig zouden zijn om verder te komen met het project en op welke manieren contacten kunnen worden gelegd met de verschillende stakeholders. **Neem hiervoor 5 minuten.**

3.

10 Minuten

Als laatste opdracht nemen jullie de tijd om te kijken naar de hoe de probleemstelling kan worden opgelost. Bespreek wat de volgende stappen zijn in het proces richting een oplossing en hoe de nieuwe student optimaal gebruik kan maken van de leercurve in zijn proces. Neem hiervoor 10 minuten.

Klaar? Neem een **foto van het bouwwerk** voor eigen documentatie!

Jullie hebben nu alle opdrachten afgerond. Om af te sluiten, bespreek met elkaar de belangrijkste inzichten die je hebt opgedaan tijdens alle opdrachten en wat je mee zal nemen uit de sessie.

Appendix G

Evaluation form prototype test

Kruis aan wat van toepassing is met betrekking tot deze test:

Student in eindfase project/Student in beginfase project/Management Urban Innovation

Algemeen

Vraag 1. Wat is je eerste indruk van de toolkit?

Voorbereiding

Vraag 2. Heb je de voorbereidingsopdracht in Miro gemaakt? Ja/Nee

Vraag 3. Op welke manieren heeft de voorbereidingsopdracht je geholpen als voorbereiding op de opdrachten met de toolkit?

Vraag 4. Welke inzichten heb je opgedaan uit de voorbereidingsopdracht?

V**raag 5**. Waren de inzichten die je hebt opgedaan uit de voorbereidingsopdracht verrassend voor jezelf? Ja/Nee

Licht toe…

Toolkit

Vraag 6. Was het duidelijk hoe je de materialen uit de toolkit kon gebruiken? Ja/Nee

Licht toe…

Vraag 7. Geef bij de plaatjes van de verschillende materialen aan waarom je deze materialen hebt gebruikt tijdens de opdrachten van de toolkit:

Het Gesprek

Vraag 8. Welke inzichten heb je opgedaan m.b.t. je eigen probleemstelling in de sessie met de toolkit?

Vraag 9. Welke inzichten heb je opgedaan m.b.t de probleemstelling van de andere student in de sessie met de toolkit?

Vraag 10. Waren de inzichten die je hebt opgedaan uit de sessie met de toolkit verrassend? Ja/Nee

Licht toe…

Vraag 11. Voor welke opdracht(en) was de tool het meest waardevol? (Meerdere antwoorden mogelijk):

Warm-up: opdracht 1	Warm-up: opdracht 2	Warm-up: opdracht 3
Ronde 1: opdracht 1	Ronde 1: opdracht 2	Ronde 1: opdracht 3
Ronde 2: opdracht 1	Ronde 2: opdracht 2	Ronde 2: opdracht 3

Leg hieronder uit waarom:

Geef aan in hoeverre je het eens bent met de volgende stellingen:

12. De probleemstellingen van de verschillende studenten in de sessie sloten op elkaar aan:

Helemaal oneens ◯ ◯ ◯ ◯ ◯ Helemaal eens

Licht je antwoord toe:

13. De kennis van de verschillende deelnemers sloot op elkaar aan:

Helemaal oneens ◯ ◯ ◯ ◯ ◯ Helemaal eens

Licht je antwoord toe:

14. De sessie met de toolkit heeft geholpen om nieuwe perspectieven op de problemen te werpen:

Helemaal oneens ◯ ◯ ◯ ◯ ◯ Helemaal eens

Licht je antwoord toe:

15. De sessie met de toolkit heeft geholpen om te reflecteren op mijn eigen kennis:

Helemaal oneens ◯ ◯ ◯ ◯ ◯ Helemaal eens

Licht je antwoord toe:

16. De sessie met de toolkit heeft geholpen om nieuwe kennis op te doen:

Helemaal oneens ◯ ◯ ◯ ◯ ◯ Helemaal eens

Licht je antwoord toe:

17. De sessie met de toolkit heeft geholpen om te reflecteren op de kennis van anderen:

Helemaal oneens ◯ ◯ ◯ ◯ ◯ Helemaal eens

Licht je antwoord toe:

18. De sessie met de toolkit heeft mijn gedachten over de probleemstelling veranderd:

Helemaal oneens ◯ ◯ ◯ ◯ ◯ Helemaal eens

Licht toe in welke maten:

Vraag 19. Hoe heb je duidelijk kunnen maken wat moeilijk met woorden uit te drukken is?

Vraag 20. Heb je nu nog het gevoel dat je iets wil delen met de andere student wat tijdens de sessie ontstaan is? Licht je antwoord toe.

Vraag 21. Heb je door de sessie het gevoel gekregen dat je nog meer wil weten van de iemand anders in de context van Urban Innovation? Licht je antwoord toe.

Vraag 22. Op welke manieren ben je geïnspireerd door het gesprek?

Vraag 23. Heb je nog opmerkingen of tips voor de toolkit?

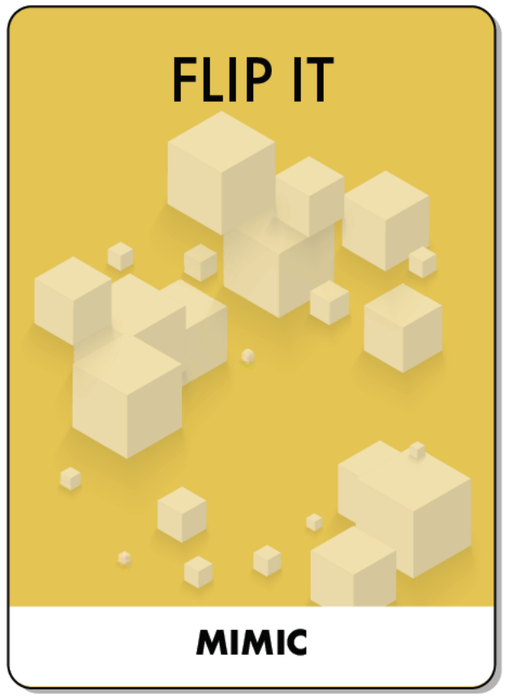
Bedankt voor het invullen!

Appendix H

Observation list prototype test

Theory	Concepts		How to observe?
Social Learning	Personal experience		- **Spoken word** - Do they speak from own experiences? (In my experience..; I have learned that..; I have seen.. etc.) - Stories or anecdotes that they tell about their own experiences - Do others react with their own stories and experiences on the story or experience that has been told (sluit het op elkaar aan?)
	Social competence		- **Spoken word and gestures** - Do they take things from each other? - Do they acknowledge others expertise? - Do they nod affirmatively - Do they question each other on knowledge? (which means they do not acknowledge others social competence)
	Engagement		- **Spoken word, observation and gestures** - Number of questions asked and number of reactions given (does not need to be a question, can also be an anecdote, idea or experience that they want to share) - Total number of interactions (questions, reactions, add something to construction) - Type of questions asked (Yes/no questions or Why?/How?) - Negotiating of meaning - Nodding affirmatively - Making an affirmative sound, like "uhuh" or "yeah" - Do they only listen or are they doing other things as well in the meantime? (building something on the side, touching other materials, looking around the room etc.)
	Alignment		- **Spoken word and building actions** - Checking if exercise is clear for everybody or if there are any questions left - Do other participants add elements to the construction that has been build?
	Imagination		- **Spoken word** - Do they reflect on their own role in the project? - Do they reflect on their own role in the knowledge network of Urban Innovation? (What they have contributed?) - Do they explore new ideas? - Do they reflect on assumptions?
Transdisciplinary Learning	Normative		- **Spoken word** - Do they explain their own purpose, concepts, knowledge and interpretations of the world -> I see the problem/world like..; In my opinion..
	Creative		- **Spoken word** - Do the participants pose actions related to their own knowledge? -> The next step is..; You should look at..; Research this..; Read this..; (if they actually followed up on these ideas is something that can be tested with an extra interview/survey)
	Descriptive		- Is the old graduate able to express HOW he approached different elements in his process? -> see also **tacit knowledge** - Reflection on the actions that are proposed and executed by new student -> something that cannot be observed in this test, but can be tested with an extra interview/survey.
	7 Habits of the mind	Perceiving	- **Spoken word** - Do the participants summarize what they observe out loud? -> If I understand correctly..; What I see on the table is..
		Patterning	- **Spoken word** - Do the participants recognize patterns or similarities? -> I recognize..; this makes me think of X that we discussed earlier..
			Abstracting	- **Spoken word** - Do the participants use analogies to explain something?
			Embodied Thinking	- **Spoken word and observation** - Do they use their senses to explain something; I see..; I feel..; I smell..; I hear..; I taste.. - Do they smell something? - Do they touch something? -> use exploratory procedures? - Do they taste something? - Do they listen carefully to something? (Do they hold something near their ears?) - Do they hold something close to their eyes to see something better?
			Modeling	- **Spoken word and Observation** - What do they use to explain something? - Do they rebuild something? - Do they use theories to explain something?
			Deep play	- **Spoken word and gestures** - Do the participants form new ideas that feel like breakthroughs? -> does the energy level go up?; is there an eureka-moment?
			Synthesizing	- **Spoken word and gestures** - Do the participants ask each other questions? - Are the participants interested in each other? -> Do they look at each other? - Also something that can be tested with a follow-up interview/survey to see if they kept in contact after the session and if they have had more discussions about their projects.
Tacit Knowledge				- **Spoken word and Time spend** - Difficulties in finding the right words to explain something - Takes more time to explain something - It is about "*HOW*", about their process, so do they explain how they tackled something? - Words used like, "from my own experience..", I did it like.." - Do the participants reflect on their process? -> "looking back at my process I think.."
Haptics	Dimensions	Texture	- Do they name the dimension when they explain something (I chose this because it feels like..) - Do they perform lateral motion (exploratory procedure)?
		Temperature	- Do they name the dimension when they explain something (I chose this because it felt hot/cold) - Words used hot/cold/warm - Do they perform static contact (exploratory procedure)?
		Shape	- Do they name the shape when they explain something (I chose the cube because..) - Words used cube, pyramid, sphere, square, circle, triangle, round - Do they perform enclosure or contour following (exploratory procedure)?
		Size	- Do they name the size when they explain something? - Comparison of sizes in explanation - Comparison of sizes when deciding which one to take
		Hardness	- Do they name the dimension when they explain something (I chose this because it feels hard or soft..) - Words used hard, soft, press in - Do they perform pressure (exploratory procedure)?
		Weight	- Do they name the dimension when they explain something (This feel heavy..) - Words used heavy, light - Do they perform unsupported holding (exploratory procedure)?
		Volume	- Do they name the dimension when they explain something (This element has a lot of content..) - Do they perform enclosure (exploratory procedure)?
		Viscosity	- Do they use the clay? - How do they use the clay?

Warming-up exercises MIMIC



FLIP IT

Haptische elementen

STAPPENPLAN

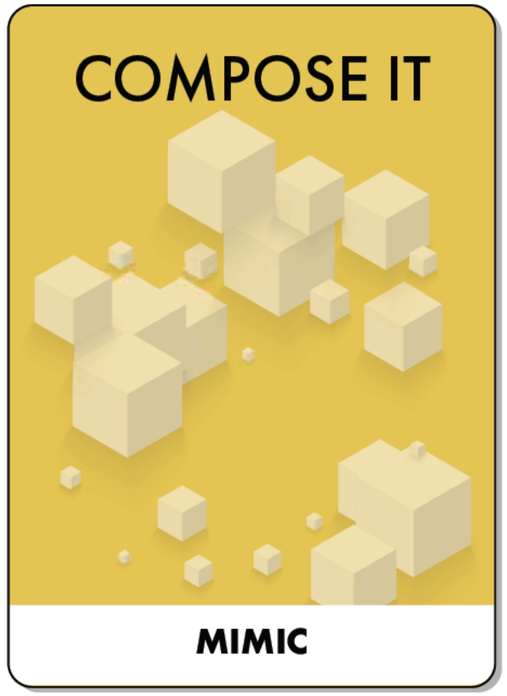
1. Kies allemaal individueel ŽŽn haptisch element
2. Met behulp van dit element gaan jullie vragen beantwoorden door de textuur die de vraag het beste beantwoord naar boven te plaatsen
   Voorbeeld *ÒHoe gaat het met je?Ó* plaatst schuurpapier naar boven *Ò Ik zit vast met mijn project, het schuurtÓ*
3. Nadat iedereen zijn haptische element heeft geflipt, leggen jullie aan elkaar je antwoord uit
4. De vragen voor deze opdracht verzinnen jullie zelf Zorg ervoor dat iedereen minstens ŽŽn vraag stelt met als doel elkaar te leren kennen
5. Alle vragen gesteld en beantwoord? Ruim de haptische elementen weer op

MIME IT

Haptische elementen

STAPPENPLAN

1. ƒ Žn persoon vertelt iets over zijn hobbies terwijl tegelijkertijd de andere deelenemers zijn verhaal nabouwen
2. Klaar? Leg ŽŽnvoor ŽŽn aan elkaar uit wat je hebt gebouwd
3. Uitleg klaar? Ruim de bouwwerken op zodat er ruimte is voor de volgende opdracht
4. Herhaal de opdracht voor de andere deelnemers zodat iedereen iets heeft vertelt over zijn hobbies
5. Helemaal klaar? Ruim de bouwwerken op zodat er ruimte is voor de volgende opdracht



COMPOSE IT

2 Min. Alle elementen

STAPPENPLAN

1. Bouw individueel in 2 minuten een bouwwerk over jezelf met de elementen van Mimic zodat er 3 bouwwerken ontstaan
2. Klaar? Leg ŽŽnvoor ŽŽn aan elkaar uit wat je hebt gebouwd
3. Uitleg klaar? Ruim de bouwwerken op zodat er ruimte is voor de volgende opdracht

BUILD IT

MIMIC

BUILD IT

2 Min.

Alle elementen + kaartendoosje

STAPPENPLAN

1. Laat ŽŽn persoon ŽŽn kaartje trekken uit het kaartendoosje
2. Bouw allemaal individueel in 2 minuten wat er op het kaartje staat met de elementen van Mimic zodat er 3 bouwwerken ontstaan
3. Klaar? Leg ŽŽn voor ŽŽn aan elkaar uit wat je hebt gebouwd
4. Uitleg klaar? Ruim de bouwwerken op zodat er ruimte is voor de volgende opdracht

STACK IT

MIMIC

STACK IT

1 Min.

Alle elementen + kaartendoosje

STAPPENPLAN

1. Bouw in 1 minuut met elkaar een bouwwerk dat niets voorstelt
2. Klaar? Trek nu allemaal individueel ŽŽn kaartje uit het kaartendoosje
3. Neem de tijd om individueel te bedenken hoe het bouwwerk hetgeen representeert wat op het kaartje staat
4. Leg ŽŽnvoor ŽŽn aan elkaar uit wat jullie bouwwerk voorstelt: *Het bouwwerk is een , omdat*
5. Uitleg klaar? Ruim de bouwwerken op zodat er ruimte is voor de volgende opdracht

MOEDER	AARDE	BOOT
KASTEEL	TENT	BOEK
HOND	CLOWN	SCHAAR
EEND	FIETS	PIANO
IJSJE	CAMERA	SLEUTEL
VOETBAL	LAMP	TUNNEL
LAPTOP	VLINDER	PEER
FORNUIS	AUTO	OLIFANT
VUUR	BLOEM	BESTEK

MOBIEL	KLOK	PAD
RUGZAK	TAART	PRIJS
SCHOEN	BUS	FAMILIE
STOEL	PLANT	KAARS

MOK	BRIL	WORTEL
MUIS	LUCHT	ZOMER
SPEL	DOEL	WINTER
GERECHT	ELF	EILAND
KATER	STER	WAPEN

MIMIC

OPDRACHTEN

Voor jullie ligt Mimic, een haptische taal die jullie gaat helpen om kennis te delen. Om jullie daar verder bij te helpen zijn er opdrachten met vragen opgesteld. Door het uitvoeren van de opdrachten en het beantwoorden van de vragen, zullen jullie nieuwe inzichten op doen en elkaar kunnen helpen met jullie projecten.

1. INTRODUCTIE

Voordat jullie in je eigen projecten duiken, is het goed om elkaar en de haptische taal te leren kennen. Hiervoor kunnen jullie gebruik maken van de warm-up opdrachten die beschreven staan op de losse kaarten. Zorg dat jullie er eentje van elke categorie (verschillende kleuren) doen en op zijn minst 1 individuele opdracht en 1 groepsopdracht (zie icoontjes).

2. PROBLEEMSTELLING

2.1 De studenten bouwen individueel in 3 minuten hun probleemstelling met Mimic.

2.2 De student die het langst bezig is met zijn project legt nu als eerste uit wat zijn probleemstelling is aan de hand van zijn bouwwerk. De andere deelnemers kunnen vragen stellen en het bouwwerk aanvullen.

2.3 De student die het minst lang bezig is met zijn project legt nu uit wat zijn probleemstelling is aan de hand van zijn bouwwerk. De andere deelnemers kunnen vragen stellen en het bouwwerk aanvullen.

2.4 Bespreek de verschillen en overeenkomsten tussen de probleemstellingen.

2.5 Zijn de probleemstellingen duidelijk voor iedereen? Ruim de bouwwerken op en ga verder naar opdracht 3.

3. PROCES

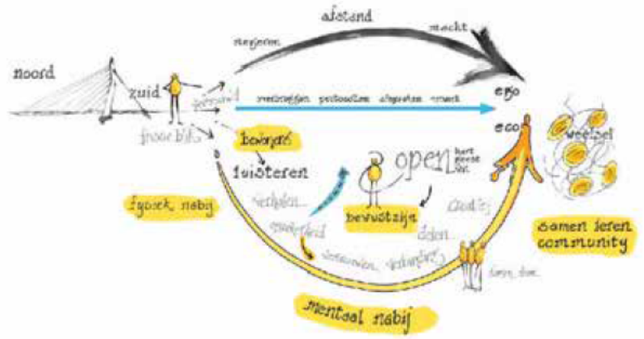
3.1 De student die het langst bezig is met zijn project bouwt in 1 minuut zijn/haar proces wat hij/zij heeft doorlopen tijdens zijn afstuderen. Dit is een eerste ruwe versie.

3.2 De student legt zijn proces uit aan de hand van zijn bouwwerk en vult het aan waar nodig zodat het een compleet geheel wordt. De andere deelnemers kunnen vragen stellen en het bouwwerk aanvullen.

3.3 De student bespreekt zijn hoogte- en dieptepunten uit zijn proces en dingen die hij/zij anders had willen aanpakken.

Ga verder op de achterkant!

3.4 De student legt als laatste uit hoe de leercurve van Urban Innovation (zie Figuur 1) terug te zien is in zijn/haar proces.



3.5 Is het proces duidelijk voor iedereen? Ruim het bouwwerk op en ga verder naar opdracht 4.

4. FUTURE PLANS

4.1 De student die net is begonnen met afstuderen bouwt in 1 minuut zijn/haar plan van aanpak voor de probleemstelling.

4.2 De student legt zijn plan van aanpak uit aan de hand van zijn bouwwerk en vult het aan of wijzigt het waar nodig. De andere deelnemers kunnen vragen stellen en het bouwwerk aanvullen of wijzigen.

4.3 Bespreek met elkaar wat de valkuilen kunnen zijn voor de student en zijn/haar project.

4.4 Bespreek met elkaar hoe de student de leercurve van Urban Innovation kan toepassen in zijn/haar proces.

4.5 Is het plan van aanpak duidelijk voor iedereen? Ruim het bouwwerk op.

Instruction sheet MIMIC

MIMIC

OVERZICHT

Hieronder vinden jullie een overzicht van alle elmenten waaruit MIMIC bestaat:

1. **WARM-UP OPDRACHTEN**

   Op deze kaartjes staan verschillende opdrachten die uitgevoerd worden aan het begin van de sessie met Mimic om zowel Mimic als elkaar te leren kennen.

2. **KAARTENDOOSJE**

   In het kaartendoosje zitten kaartjes met woorden die gebruikt kunnen worden bij sommige warm-up opdrachten.

3. **BASIS ELEMENTEN**

   De basis elementen zijn gemaakt van hout in drie verschillende afmetingen. De elementen hebben ook verschillende gewichtjes. De afmetingen en het gewicht van de elementen kunnen gebruikt worden voor het bouwen.

4. **HAPTISCHE ELEMENTEN**

   De haptische elementen zijn er ook in drie verschillende afmetingen en hebben allemaal 6 verschillende zijdes met texturen. De afmetingen en de texturen van de elementen kunnen gebruikt worden voor het bouwen.

MIMIC

TIPS & TRICKS

Hieronder vinden jullie belangrijke tips & tricks die jullie helpen nog meer uit MIMIC te halen, naast het volgen van de opdrachten. Lees ze goed door en ga dan lekker aan de slag!

1. **HAPTSICHE ELEMENTEN OPTIMAAL BENUTTEN**

   Als je de haptische elementen gebruikt in je bouwwerk, denk dan na over hoe alle zijdes die zichtbaar zijn passen in je bouwwerk. Daarnaast kan je natuurlijk ook een reden hebben waarom je een bepaald materiaal juist niet laat zien in je bouwwerk. Neem deze gedachtes ook mee in je uitleg!

2. **BASIS ELEMENTEN OPTIMAAL BENUTTEN**

   De basis elementen hebben verschillende gewichten. Deze eigenschap kun je ook gebruiken om dingen duidelijk te maken. Laat maar eens voelen aan de anderen hoe zwaar een bepaalde stap was in je project.

3. **DAAG ELKAAR UIT**

   Daag elkaar uit om dieper na te denken over hetgeen iemand aan het uitleggen is door kritische vragen te stellen. Daarnaast kan je iemand ook eens blind elementen laten voelen om te kijken welk materiaal of gewicht dan het beste zijn gedachten weergeeft.

4. **BOUW SAMEN**

   Zodra iemand een eerste versie heeft gebouwd, is het belangrijk om allemaal een actieve houding aan te nemen en ook het bouwwerk te veranderen en aan te vullen. Dit zorgt ervoor dat degene die zijn verhaal verteld dieper moet nadenken en reflecteren, wat zorgt voor nieuwe inzichten.

5. **CHECK OP DUIDELIJKHEID**

   Check altijd aan het einde van een opdracht of alles voor iedereen duidelijk is zodat iedereen optimaal mee kan blijven doen en denken.

6. **MAAK NOTITIES**

   Neem iets om notities te maken om je nieuwe inzichten en gedachten vast te leggen. Dit kan je helpen om later nog eens te reflecteren en zorgt ervoor dat je blijft leren. Je kan ook foto's maken tussendoor!

Project Brief

4536

DESIGN FOR our future

TU Delft

IDE Master Graduation

Project team, Procedural checks and personal Project brief

This document contains the agreements made between student and supervisory team about the student's IDE Master Graduation Project. This document can also include the involvement of an external organisation, however, it does not cover any legal employment relationship that the student and the client (might) agree upon. Next to that, this document facilitates the required procedural checks. In this document:

- The student defines the team, what he/she is going to do/deliver and how that will come about.
- SSC E&SA (Shared Service Center, Education & Student Affairs) reports on the student's registration and study progress.
- IDE's Board of Examiners confirms if the student is allowed to start the Graduation Project.

USE ADOBE ACROBAT READER TO OPEN, EDIT AND SAVE THIS DOCUMENT

Download again and reopen in case you tried other software, such as Preview (Mac) or a webbrowser.

STUDENT DATA & MASTER PROGRAMME

Save this form according the format "IDE Master Graduation Project Brief_familyname_firstname_studentnumber_dd mm yyyy"
Complete all blue parts of the form and include the approved Project Brief in your Graduation Report as Appendix 1 !

family name: Sillekens
initials: J.L.M. given name: Jolien
student number: 4268652
street & no.: [redacted]
zipcode & city:
country:
phone:
email:

Your master programme (only select the options that apply to you):
IDE master(s): ( ) IPD ( ) DfI (★) SPD
2nd non-IDE master: Science Communication
individual programme: - - (give date of approval)
honours programme: ( ) Honours Programme Master
specialisation / annotation: ( ) Medisign
( ) Tech. in Sustainable Design
( ) Entrepreneurship

SUPERVISORY TEAM **

Fill in the required data for the supervisory team members. Please check the instructions on the right !

** chair: dept. / section: HCD
** mentor: Katrina Heijne dept. / section: DO5
2nd mentor: organisation: city: country:
comments (optional):

Chair should request the IDE Board of Examiners for approval of a non-IDE mentor, including a motivation letter and c.v.

Second mentor only applies in case the assignment is hosted by an external organisation.

Ensure a heterogeneous team. In case you wish to include two team members from the same section, please explain why.

TU Delft

Procedural Checks - IDE Master Graduation

APPROVAL PROJECT BRIEF

To be filled in by the chair of the supervisory team.

chair: Maarten Wijntjes date: 18 - 9 - 2020 signature:

CHECK STUDY PROGRESS

To be filled in by the SSC E&SA (Shared Service Center, Education & Student Affairs), after approval of the project brief by the Chair.
The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total: 28 EC
Of which, taking the conditional requirements into account, can be part of the exam programme: 28 EC
List of electives obtained before the third semester without approval of the BoE:

(X) YES all 1st year master courses passed
( ) NO missing 1st year master courses are:

name: C. van der Bunt date: 30 - 10 - 2020 signature: CB

FORMAL APPROVAL GRADUATION PROJECT

To be filled in by the Board of Examiners of IDE TU Delft. Please check the supervisory team and study the parts of the brief marked **.
Next, please assess, (dis)approve and sign this Project Brief, by using the criteria below.

- Does the project fit within the (MSc)-programme of the student (taking into account, if described, the activities done next to the obligatory MSc specific courses)?
- Is the level of the project challenging enough for a MSc IDE graduating student?
- Is the project expected to be doable within 100 working days/20 weeks ?
- Does the composition of the supervisory team comply with the regulations and fit the assignment ?

Content: (V) APPROVED ( ) NOT APPROVED
Procedure: (V) APPROVED ( ) NOT APPROVED
comments:

name: Monique von Morgen date: 9/11/2020 signature: MvM

Personal Project Brief - IDE Master Graduation

TU Delft

Improve communication between stakeholders with a haptic language — project title

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date 18 - 09 - 2020 — 07 - 05 - 2021 end date

INTRODUCTION **

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

Rotterdam is a city that is constantly reinventing itself with a strongly changing population composition and an enormous building and design drive. The problematic side of this is that some of its residents have not been able to keep up with the changes and have suffered great social and economic disadvantage, Rotterdam South in particular. Solving this not only requires time, but also more cohesion in expertise.

EMI, which stands for Expertisecentrum Maatschappelijke Innovatie ("Centre of Expertise Societal Innovation") is established by Hogeschool Rotterdam and connects education with these complex societal problems in Rotterdam South. The solutions that the students create in combination with practical partners and the residents of Rotterdam South, contribute to improving the living conditions of this area and help to solve the complex societal problems. The collaboration between the students, lecturers, researches, practical partners and residents happens in so-called Communities of Practice [1].

EMI has five different programs, 1. Education, 2. Work, 3. Care &Welfare, 4. Housing and 5. Art & Culture. Within these programs, the students work on a variety of projects, see figure 1.

Within the EMI-program Urban Innovation (Housing) it became clear that the potential of two-sided learning - in which the student learns from and contributes to practice in South - was usually not realized. This gave rise to the idea of creating a learning community where research, design, education and practice can meet. The program has shifted from an area-oriented approach to a neighborhood-oriented approach when it comes to urban issues. This means that they do not focus on problems of the whole area Rotterdam South, but zoom into the different neighboorhoods and the problems that arise there. Through this bottom-up approach, Urban Innovation works on an interactive and equal learning community.

Building the learning community started in 2020, from the new Wijkstudio. The added value of this method is already noticeable in the start-up phase:
1. Students indicate that they feel more involved in urban issues,
2. Lecturers notice an increase in environmental sensitivity among students, partly due to changes in attitude and language use,
3. Residents and entrepreneurs feel that they are taken more seriously,
4. Practice partners appreciate the proximity of the students when collaborating on the assignments.

Collaboration is something everyone seems to find important, but still has little priority for many. Also, when different parties meet, differences become clear and different experiences and expertise can cause disagreements. Therefor it is important to consciously manage partnerships and that is what EMI would like to achieve with this learning community. Although, great things have been achieved already, EMI needs to keep working on fruitful collaborations, especially in their communication with residents, so they feel heard and understand why certain decisions are being made and to make sure residents are willing to collaborate in future projects.

Source:
1. 1. EMI. (n.d.). EMI. Retrieved September 10, 2020, from https://www.emiopzuid.nl/info-201/home/

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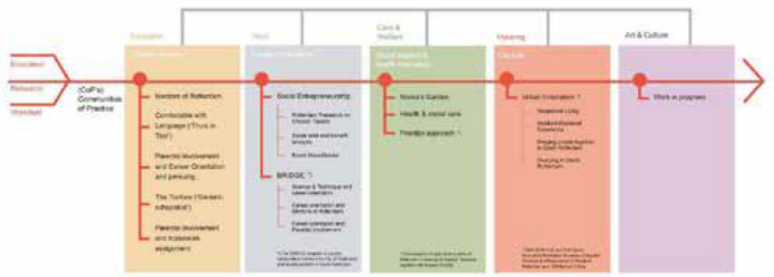


image / figure 1: Overview of projects from EMI within the five programs

TO PLACE YOUR IMAGE IN THIS AREA:
- **SAVE THIS DOCUMENT TO YOUR COMPUTER AND OPEN IT IN ADOBE READER**
- **CLICK AREA TO PLACE IMAGE / FIGURE**

PLEASE NOTE:
- **IMAGE WILL SCALE TO FIT AUTOMATICALLY**
- **NATIVE IMAGE RATIO IS 16:10**
- **IF YOU EXPERIENCE PROBLEMS IN UPLOADING, COVERT IMAGE TO PDF AND TRY AGAIN**

image / figure 2:

Personal Project Brief - IDE Master Graduation

TU Delft

PROBLEM DEFINITION **

Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

Research question: How to improve face-to-face collaborations, with a haptic language, between students and residents of Rotterdam South within Urban Innovation projects to create a better understanding of the problems the residents face and the solutions the students design.

Within my graduation project I want to contribute to more fertile collaborations between students and residents. Within these collaborations the students try to deal with complex social problems. Conklin (2005) explains that the 'Holy Grail' of effective collaboration in (multidisciplinary) design teams, dealing with complex problems, is "in creating shared understanding about the problem, and shared commitment to the possible solutions" (p. 15). Common knowledge is needed to gain shared understanding and, therefore, 'knowledge boundaries' have to be crossed.

Boundary objects can help transferring knowledge across boundaries (Carlile, 2002, 2004). Boundary objects can take many forms, but as Star and Griesemer write: "Boundary objects are objects which are both plastic enough to adapt to local needs and the constraints of the several parties employing them, yet robust enough to maintain a common identity across sites" (Ibid, p. 393). This is where the idea of a haptic language comes in as a boundary object to transfer knowledge between students and residents.

Haptics is based on touch, one of the senses of the human and deepens the experience. That is why I think it can also deepen the quality of mutual cooperation and interaction. It will be a physcial tool that can be touched and moved during face-to-face interactions and discussions. Feeling emotions can also help to create understanding. With a haptic language, I think it is easier to transfer certain emotions between students and residents, which can better explain the reasoning behind the needs and wishes of these residents and create mutual understanding.

ASSIGNMENT **

State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, ... In case of a Specialisation and/or Annotation, make sure this assignment reflects this/these.

The goal of the assignment is to deliver a haptic language that the students can use as a tool to improve their communication with the residents, meaning the students are better able to understand the needs and wishes of the residents, put the residents even more central in their projects and make the residents feel more heard and taken seriously.

To achieve this the assignment consists of different parts (based on the double diamond):
1. First an understanding of the current collaboration needs to be understood, how are students and residents currently communicating, how all other parties are involved in the process, what works within this collaboration, what does not, and understanding the why behind it. (Discover)
2. From this analysis of the collaboration, the problems that need to be solved can be defined. (Define)
3. An understanding of haptics and how it can contribute to collaboration and communication needs to be researched. (Discover)
4. From the understanding of haptics, principles will be established for a haptic language. (Define)
5. With the defined problems and principles a design for a haptic language can be made, which will be iteratively tested and evaluated with the end-users. (Develop)
6. A final design for the haptic language will be delivered with recommendations on how it is best used. (Deliver)

Initials & Name J.L.M. Sillekens Student number 4268652

Title of Project Improve communication between stakeholders with a haptic language

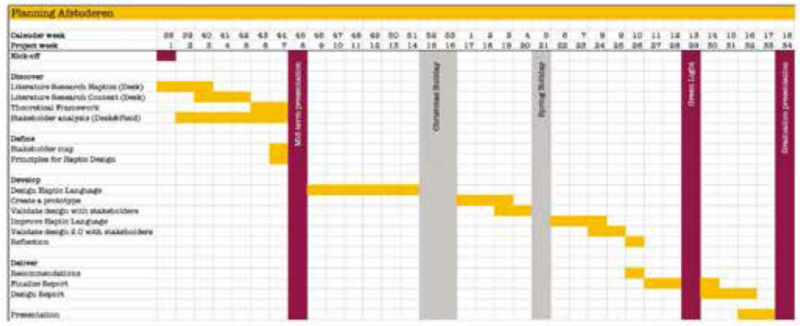
Personal Project Brief - IDE Master Graduation

TU Delft

PLANNING AND APPROACH **

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.

start date 18 - 9 - 2020 7 - 5 - 2021 end date



This planning is based on a double degree graduation project of 45 ECTS with 150 working days, so 30 full time weeks. The Mid-term presentation is scheduled after roughly 40 working days, which is in line with a normal graduation project of 20 full time weeks. The Green light is scheduled roughly 4 weeks before graduation.

This schedule includes 2 holidays that correspond to the holidays of TU Delft, the christmas break and the spring break in February. Within these holidays I will not work on my graduation project. For the rest of the weeks I will be working full-time on my graduation.

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MOTIVATION AND PERSONAL AMBITIONS

Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed. Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology; . Stick to no more than five ambitions.

Motivation:
Since I was little, I have a fascination for collaborations between different professions. As kid I thought it would not be so hard to make collaborations go smoother, but now I have grown up I have noticed how hard it can be to establish good collaborations in a world that is driven on innovations with a rapid pace. It feels there is simply no time to listen to each other and to build a relationship between stakeholders.

However, I still believe a lot can be won with better collaborations and solutions are not far away. I see communication as a key element for better collaborations and putting the human central. That is why I combined my Industrial Design Engineering with a Science Communication master. During the elective creative facilitation I have noticed how much I love to bring people together to create new ideas and to help them to get the best out of their collaboration together. During my internship I have developed a creative session to establish better collaborations within teams. With this graduation project I want to dive deeper into the subject of establishing better collaborations by the means of co-creation with designing a new tool, a haptic language.

Personal learning ambitions:
1. Within this project I want to learn how I can execute a thorough literature research and establish principles from it. The next step is to translate those principles in a design. So, I want to become better in translating theory into practice.

2. I want to enhance my interviewing skills so I am able to ask questions that will give me deeper insights and to be able to improvise on the spot when necessary. I am not a quick and flexible thinker, I often need quite some time to process what someone else is saying and how to respond to that.

3. I want to design with and for the end-user. Within my Strategic Product Design Master, the user was a bit out of side and it was more about organisations as a whole. Within this graduation project I really want to involve the end-user as soon as possible in the design process and put the user central again. This will also enhance my co-creation skills.

4. My last learning ambition is to practice in bridging professions, which I think I can practice by bridging 4 supervisors within this integrated master project. All my supervisors have their own expertise and their own way of working and I need to make sure to satisfy them all, while also doing what I want and love to do, it is after all, my graduation.

FINAL COMMENTS

In case your project brief needs final comments, please add any information you think is relevant.

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