Reducing the environmental impact of gloves used in the Intensive Care Unit

Towards greener ICUs

APPENDIX

Integrated Product Design
by Lisanne van den Berg

Appendix List

Appendix A: project approach

Appendix A.1: project brief

The formal start of the graduation project was the kick-off meeting. At the kick-off meeting, the proposal for the project was discussed, to make sure it is clear to everyone involved what I was planning to do and which outcomes I aimed for. The information was included in the project brief. During the kick-off meeting, the project brief was discussed and adjusted. On the following pages the signed project brief can be found.

Appendix A.2: project approach

Figure A.2 shows an elaborated project approach that was followed initially. The visualisation of the project shows which steps are taken and which information is used for a certain part of the project.

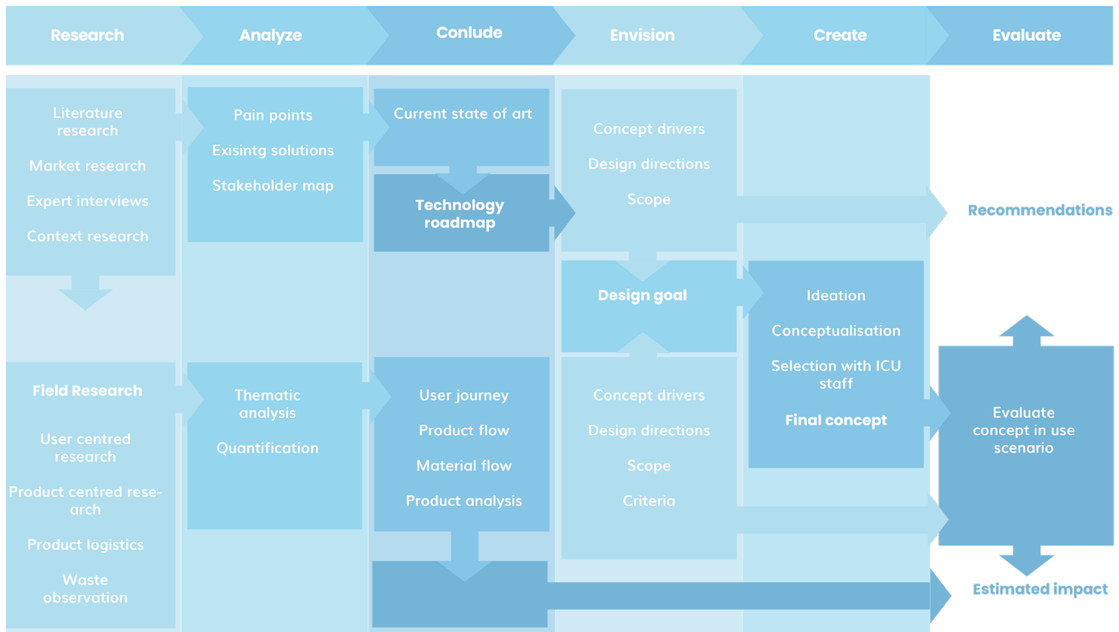

Figure A.1: Initial project approach

DESIGN FOR our future

TUDelft

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: van den Berg
initials: A.E. given name: Lisanne
student number: 4561937
street & no.:
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:
individual programme: - - (give date of approval)
honours programme: ☐ Honours Programme Master
specialisation / annotation: ★ Medisign
☐ Tech. in Sustainable Design
☐ Entrepeneurship

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

** chair: Jan Carel Diehl dept. / section: SDE
** mentor: Armagan Albayrak dept. / section: HCD
2nd mentor: Nicole Hunfeld
organisation: Erasmus MC
city: Rotterdam country: Netherlands

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.

APPROVAL PROJECT BRIEF

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

chair Jan Carel Diehl date 07 - 09 - 2021 signature jdiehl Digitally signed by jdiehl Date: 2021.09.07 10:59:24 +02'00'

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: 27 EC

Of which, taking the conditional requirements into account, can be part of the exam programme 27 EC

List of electives obtained before the third semester without approval of the BoE

★ YES all 1st year master courses passed

NO missing 1st year master courses are:

name C. van der Bunt date 13 - 09 - 2021 signature C. van der Bunt Digitally signed by C. van der Bunt Date: 2021.09.13 11:54:20 +02'00'

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: ★ APPROVED NOT APPROVED

Procedure: ★ APPROVED NOT APPROVED

comments

name Monique von Morgen date 28 - 09 - 2021 signature

Reduction of the environmental impact of gloves in the Intensive Care Un — 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 06 - 09 - 2021 24 - 01 - 2022 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, ...).

The healthcare sector provides us access to high-quality healthcare, but is also responsible for a severe environmental impact. Currently, the healthcare sector is one of the most carbon intensive sectors, contributing to 4,4% of global net greenhouse gas emissions and toxic air pollutants (Karliner, 2019).

The Erasmus Medical Center (MC) in Rotterdam and the Faculty of Industrial Design Engineering of the TU Delft have initiated a series of graduation projects to design sustainable solutions specifically for the Intensive Care Unit (ICU). To recover from life-threatening illnesses and injuries, patients need the utmost attention and care at the ICU. The complexity of treatments in combination with the pressure on staff makes the ICU one of the most resource-intensive departments of the hospital (Metabolic, 2021)

Recently, a material stream analysis has been made of the ICU to map all products used (and disposed) to assess the current environmental impact. Several 'hotspots' have been identified. One of them is 'disposable gloves', see figure 1. Disposable gloves are used to protect from contaminated materials and chemicals. 108 disposable gloves are used on average per day, per patient in the ICU(Metabolic, 2021). Roughly two types of disposed gloves can be distinguished:

Non-used gloves: Gloves are packed in a box of 100. When the ICU is cleaned, the dispensers are disposed including non-used gloves due to health safety protocols. Also, unintendedly nurses take too many gloves out of the packaging. Or when the expiration date is over.

Used gloves: Some of them get in contact with patients, some others not. The main impact is created due to material consumption (only nitrile) as well as created (contaminated) waste.

Stakeholders involved are; single use gloves manufacturers, medical equipment manufacturers, procurement, ICU team, waste management team, policy makers and other departments at the Erasmus MC

The adapted model of the Value Hill model can be used to describe the main opportunities to reduce the environmental impact of the gloves, see figure 2. The environmental impact of manufacturing and use of nitrile gloves can be reduced or redesigned. Or on the right; the process after use can be changed.

Due to the medical setting, limitations needs to be considered; medical standards, cross contamination, accessibility, protocols, ergonomics, function, logistics and adaption.

Sources:
Browne-Wilkinson, S., van Exter, P., Bouwens, J., Souder, J., & Chatel, E. (2021). Circular Intensive Care Unit - opportunities for human and planetary health. Metabolic and Erasmus MC.

Karliner, J., Slotterback, S., Boyd, R., Ashby, B., Steele, K., & Wang, J. (2020). Health care's climate footprint: the health sector contribution and opportunities for action. European Journal of Public Health, 30(Supplement_5). https://doi.org/10.1093/eurpub/ckaa165.843

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introduction (continued): space for images

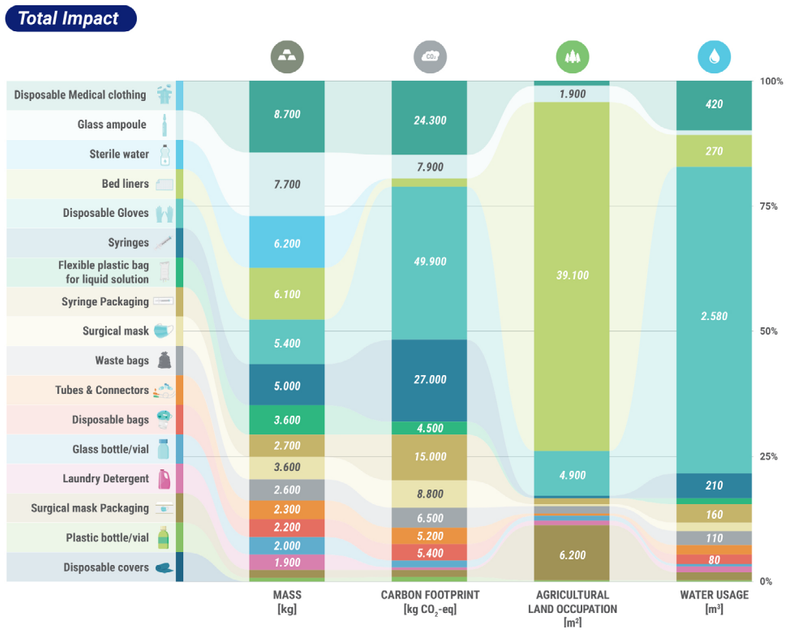
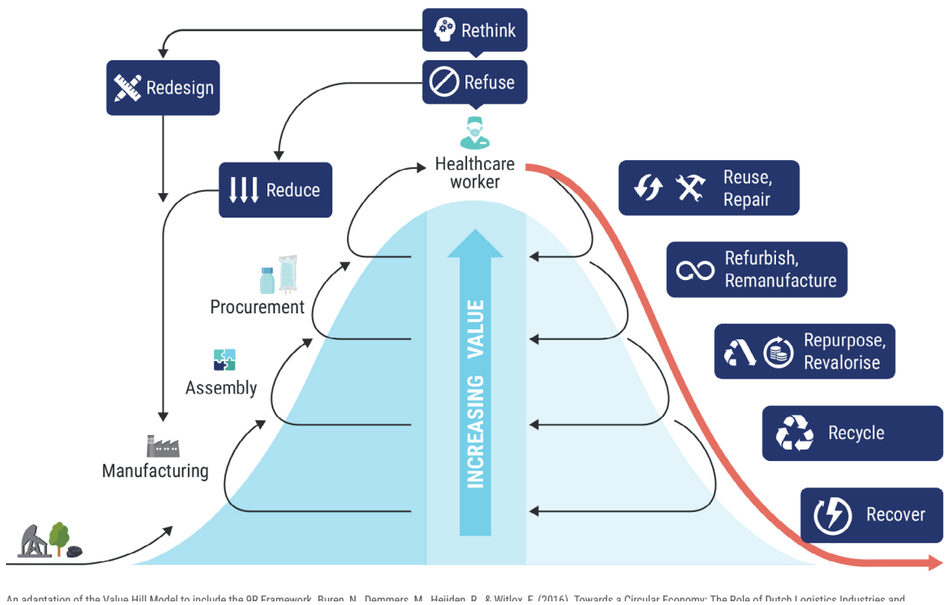


image / figure 1: Estimated contribution of the most important product groups (Metabolic, 2021)



An adaptation of the Value Hill Model to include the 9R Framework. Buren, N., Demmers, M., Heijden, R. & Witlox, F. (2016). Towards a Circular Economy: The Role of Dutch Logistics Industries and

image / figure 2: Value Hill model showing how the R-strategies can be used (Metabolic, 2021)

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.

The Intensive Care Unit is one of the most resource-intensive departments of the hospital. The scope of this project will be narrowed down to the problem area of disposable gloves. Disposable gloves do have a major contribution to the environmental impact created by the ICU. The main impact is created due to material consumption (only nitrile) as well as created (contaminated) waste.

The reliance on a linear supply chain through continued use of "disposable" gloves holds back the transition towards a more sustainable Intensive Care Unit (ICU).

The problem of this graduation project can be defined as; the linear use of disposable gloves in the Intensive Care Unit contributes too much to a negative environmental impact. The negative environmental impact should be decreased.

It needs to be researched first why and how gloves are disposed, to subsequently investigate and generate environmental sound solutions with a wide variety of strategies.

The solution space is still open, and will be based on the analysis. However it can be narrowed down to ideas/design that can have a direct impact and can be applied in the Erasmus MC. Opportunities to improve, but don't have a direct impact for the Erasmus MC, will be presented as recommendations.

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 the assignment reflects this/these.

I am going to research first why and how gloves are disposed, to subsequently investigate and generate environmental sound solutions with a wide variety of strategies. Awareness will be created for solution spaces, and concepts will be generated.

I am going to research first why and how gloves are disposed, to subsequently investigate and generate environmental sound solutions with a wide variety of strategies.

Goal of this project is to steer the ICU towards a more circular one and to create awareness for solution spaces. The focus is on research and analysis of the current situation to be able to define solution spaces.

From the analysis I aim to deliver a nurse journey (human factors, protocols), product journey and material flow. These flows in combination with the value hill and R-strategies defines starting points for solutions.
Solution spaces outside the Erasmus MC will be worked out as recommendations. Solution spaces that could have a direct impact on the Erasmus MC can be worked out into ideas and concepts. The ideas will be validated and the impact on the reduction of the environmental impact will be estimated. The flows / journeys will be recurring in this process.

Examples of final designs could be:
- A concept for reducing the use of gloves
- A concept for preventing disposal of unused gloves (new dispenser, protocol change)
- A concept for recycling gloves

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.

I got really enthusiastic by the graduation, because it is a project which combines two of my interest; healthcare and sustainability. As a medisign student I want to graduate in the medical field. It is my ambition to combine this current conflicting field of high medical standard and sustainability into an area that goes together. I want to apply my gained knowledge in medical standards from the course “Rules and regulations of medical devices”. Also, I want to apply my knowledge of circular business models into my project.

This project is not about one specific product feature, but about observing and research a bigger context. During my medical minor, I did a project about infection prevention. The task was to observe a whole department. I want to use those skills in this project. Dividing and combining the data of the different flows and journeys is an exciting challenge for me.

I want to stay in the research phase for a longer period; to gain in depth knowledge about the standards and protocols of the ICU. So, the focus is on research and finding solution areas.

Lastly, I would like to work on my (visual) communication skills; to visualise and communicate ideas, problems and results, so that others will immediately understand it. I want to visualise the impact of the design interventions in the visuals. The visualisation of the data is quite a challenge, because there is not an existing format.

FINAL COMMENTS

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

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 6 - 9 - 2021 24 - 1 - 2022 end date

As mentioned the assignment has two challenges: to map why and how gloves are disposed of, and to investigate and generate solutions
The project is divided into four phases. First the understanding phase, to understand and gather data. Then I am going to analyse the situation; I am not only going to map materials streams, but also human factors, product factors, rules and regulation related factors and supply chain factors. The analysation is divided into three flows/journeys; a nurse journey, a product journey and a material flow.
After doing research the data will be analysed and problems will be prioritised and categorised on the value hill. Resulting in creating awareness for the problem areas and recommend the solution areas, which are out of my scope. Then, I will define which solution space(s) I will tackle, resulting in a problem statement and goal of the design project. Followed up by different ideation methods and creative session. Together with the medical staff I will select ideas to go on with.
In the last phase, I will test the prototype and evaluate the concept and recommend how the concept can be improved. The design intervention can be placed into the flow/journey. The impact on the reduction of the environmental impact will be estimated.
It is my plan to graduate in 20 weeks. I planned two holidays; one in week 44 and one during the Christmas in week 1. During the project I will work on Monday and Tuesday in the green office at the convergence in Erasmus MC. The other days I will work at working spaces in IDE.
A weekly meeting with Nicole Hunfeld (Erasmus) and Jan Carel Diehl (TU Delft) and the other graduation students involved. With Armagan Albayrak (mentor) and Jan Carel Diehl (chair) I plan to have weekly meetings. Furthermore, every two weeks I will participate in a meeting with the Green Team from Erasmus.

Appendix B: Sensitizing material

Appendix B.1: Sensitizing booklets

Over dit onderzoek

Hi,

Ik ben Lisanne van den Berg en ik studeer Integrated Product Design met een specialisatie in medisch ontwerpen. Tijdens mijn studie heb ik voor meerdere medische doeleinden producten mogen ontwerpen. En nu mag ik aan de slag voor de Intensive Care in het Erasmus MC!

Voor mijn afstudeerproject ga ik onderzoeken hoe de impact op het klimaat door wegwerp handschoenen verminderd kan worden. Per dag worden er namelijk gemiddeld 108 handschoenen per patiënt weggegooid!

Om tot een goed ontwerp te komen moet ik natuurlijk eerst weten hoe een werkdag voor een IC verpleegkundige eruit ziet en wat voor jullie belangrijk is. Om jullie beter te leren kennen heb ik 5 korte opdrachten gemaakt. Hopelijk kunnen we deze later bespreken.

Alvast bedankt!

Groetjes,
Lisanne

Goed om te weten

Het invullen van dit boekje duurt ongeveer 20 minuten.

Er zijn geen goede én foute antwoorden, het gaat om jou eigen ervaringen.

Denk niet te lang na over de vragen, schrijf je eerste gedachtes op

Wanneer je vragen, opmerkingen, tips hebt over mijn onderzoek, neem dan gerust contact met mij op

06-81562187

A.E.vandenberg@student.tudelft.nl

Dit ben ik

Naam:
.....
.....

Leeftijd:.....

Functie: .....
.....
.....

Ik werk hier al ..... jaar:
.....
.....

Dit vind ik het leukste aan mijn werk: .....
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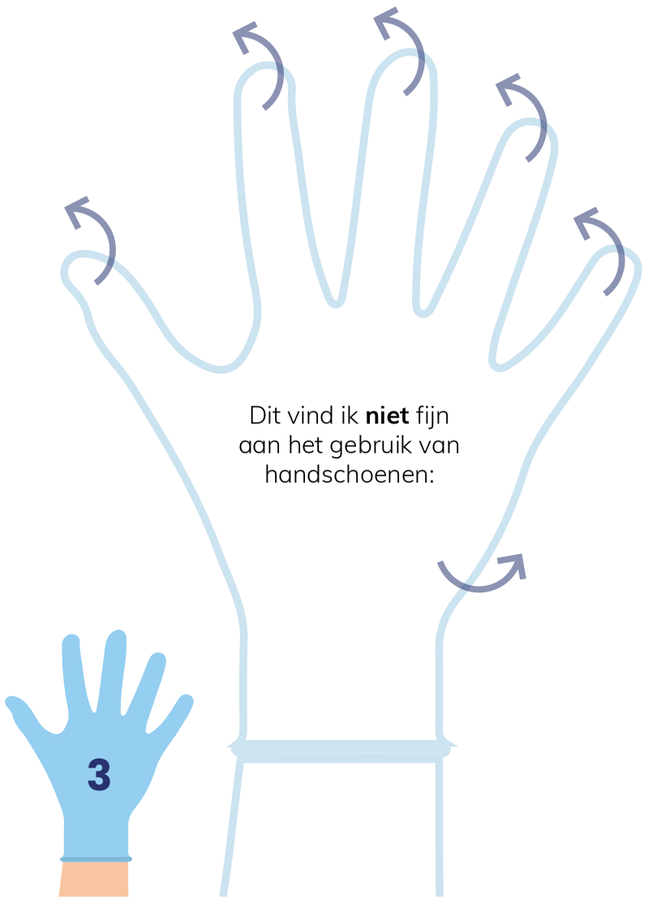
.....
.....
.....
.....

Wegwerp handschoenen

Wegwerp handschoenen



Stellingen

Hieronder staan een aantal stellingen. Kruis aan wat het beste bij jou past:

Ik gebruik wel eens handschoenen wanneer het niet nodig is

o Nooit o Zelden o Soms o vaak o Heel vaak

Ik vind de huidige werkwijze wat betreft handschoenen prima

o helemaal oneens o oneens o neutraal o eens o helemaal mee eens

Ik sta open voor veranderingen in het handschoenen gebruik

o helemaal oneens o oneens o neutraal o eens o helemaal mee eens

Het klimaat is een belangrijk onderwerp voor mij

o helemaal oneens o oneens o neutraal o eens o helemaal mee eens

Dit zou ik moeten weten

Vervolg

Heel erg bedankt voor het invullen van dit boekje. De informatie is heel waardevol voor mijn ontwerpproces.

Zou ik contact met je mogen opnemen, om deze antwoorden (in een bijeenkomst) te bespreken?

○ Nee

○ Ja, graag via:

Mobiel: .....

Mail: .....

Opmerkingen: .....
.....
.....
.....
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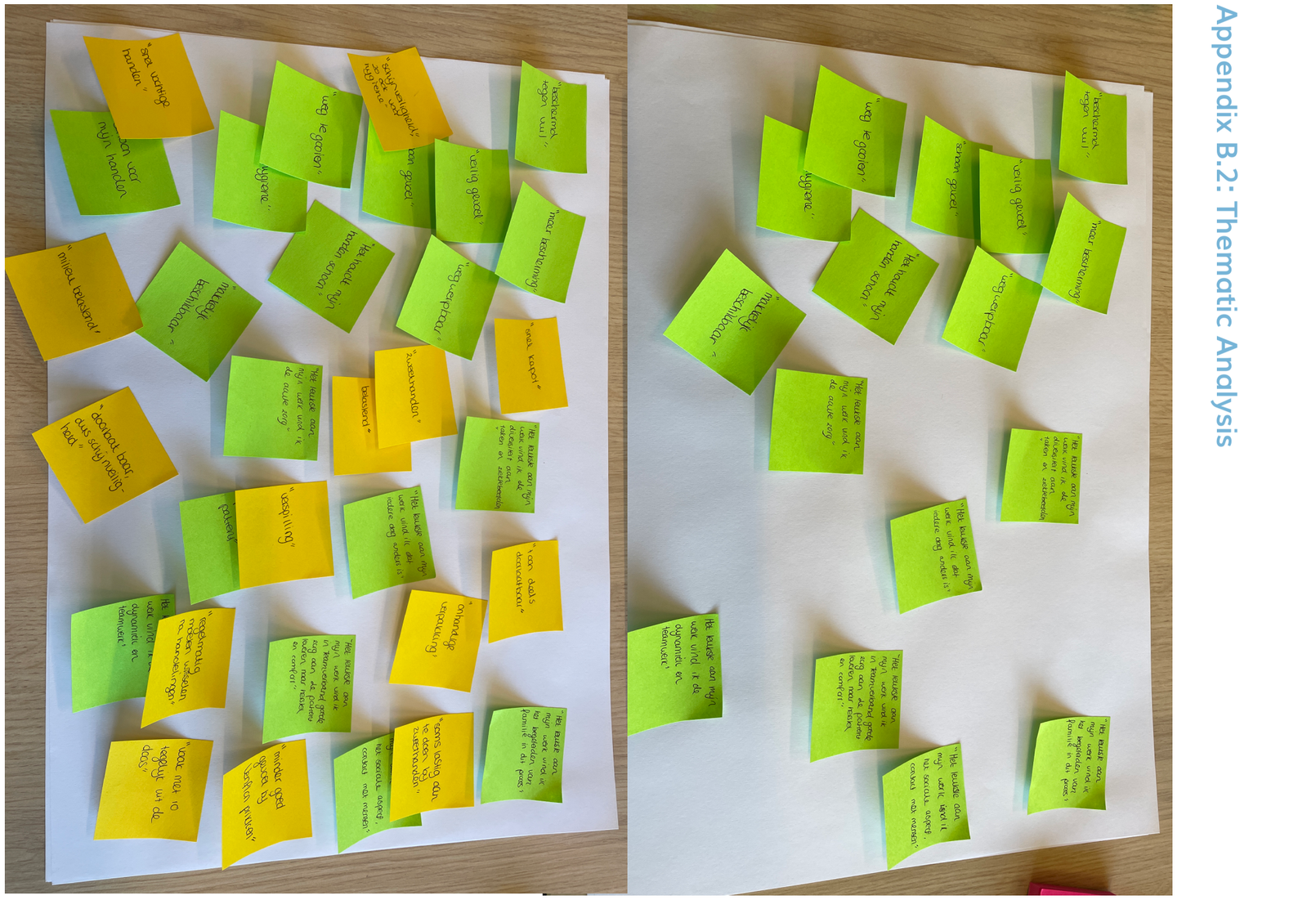
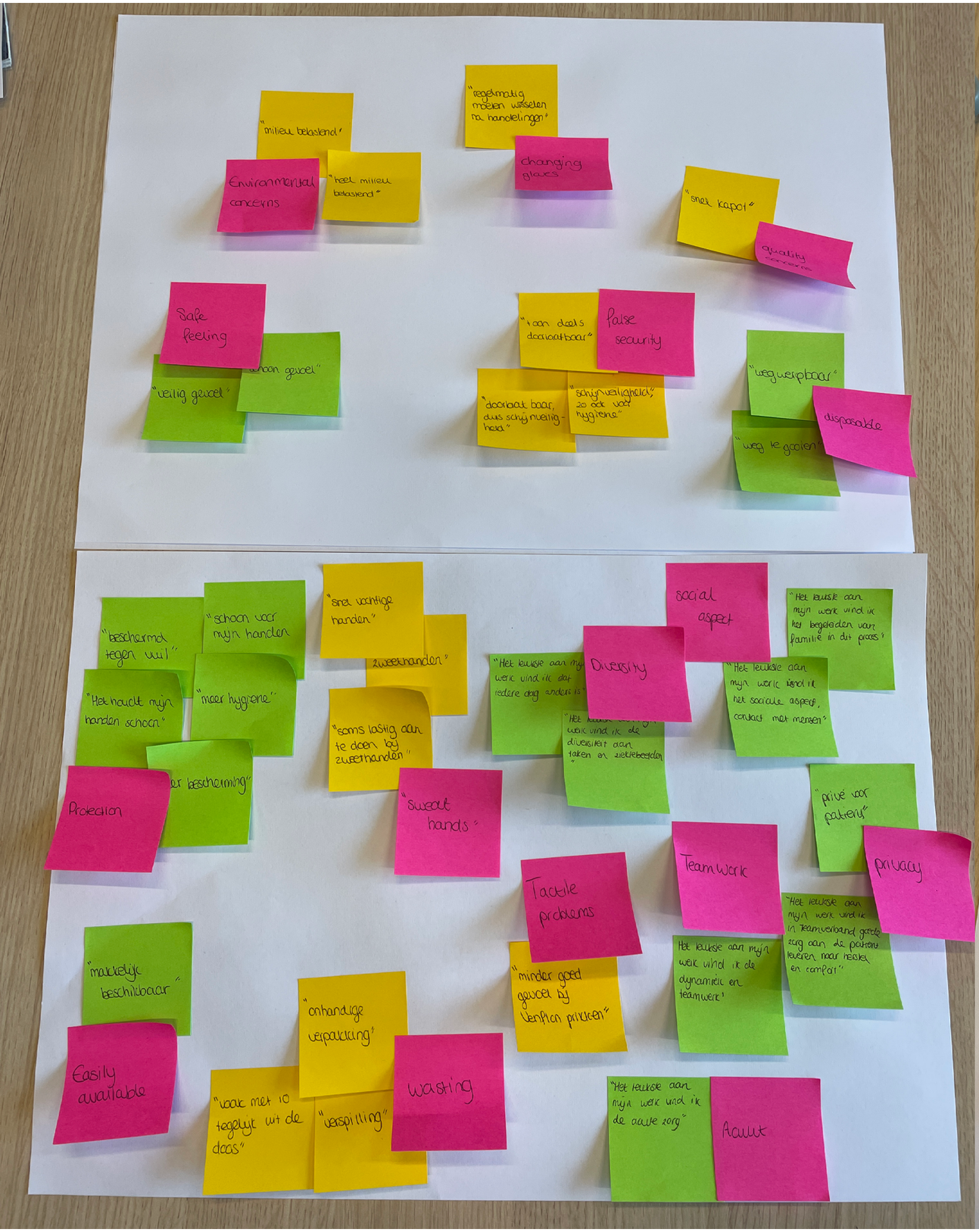
.....

Appendix B.2: Thematic Analysis




"milieu belastend"
Environmental concerns
"heel milieu belastend"
"regelmatig molen wisselen na handelingen"
changing gloves
"snel kapot"
quality concerns
Safe feeling
"veilig gevoel"
"schoon gevoel"
"van deals doorlaatbaar"
False security
"doorlaat baar, duus schijnveilig-heid"
"schijnveiligheid; zo ook voor hygiene"
"wegwerpbaar"
"weg te gooien"
disposable
"beschermd tegen vuil"
"Het houdt myn handen schoon"
"meer hygiene"
"schoon voor myn handen"
"snel vochtige handen"
2 weekhanden"
"soms lastig om te doen bij zweethanden"
Protection
"sweaty hands"
social aspect
Diversity
"Het leukste aan myn werk vind ik dat iedere dag anders is"
"Het leukste aan myn werk vind ik de diversiteit aan taken en ziektebeelden"
"Het leukste aan myn werk vind ik het begeleiden van familie in dit proces"
"Het leukste aan myn werk vind ik het sociale aspect, contact met mensen"
"private voor patiënt"
privacy
Tactile problems
Team work
"Het leukste aan myn werk vind ik in teamverband goede zorg aan de patiënt leveren, naar resultaat en comfort"
"Het leukste aan myn werk vind ik de dynamiek en teamwerk"
"minder goed gevoel bij verpleegkundige"
"makkelijk beschikbaar"
Easily available
"onhandige verpakking"
"vaak met 10 tegelijk uit de doos"
"verspilling"
warsting
"Het leukste aan myn werk vind ik de acute zorg"
Acuut

Cluster	Theme	Sub Theme	Quote
Useful aspects of working on the ICU	Social job	Social aspect	“Het leukste aan mijn werk vind ik het begeleiden van familie in dit proces” “Het leukste aan mijn werk vind ik het sociale aspect, het contact”
		Teamwork	“Het leukste aan mijn werk vind ik de dynamiek en teamwerk”
	Different situations	Acute	“Het leukste aan mijn werk vind ik de acute zorg”
		Diversity	“Het leukste aan mijn werk vind ik dat het iedere dag anders is” “Het leukste aan mijn werk vind ik de diversiteit aan taken en ziektebeelden”
Positive aspect of working with non-sterile gloves	Ease of use	Availability	“Makkelijk beschikbaar”
		Disposable	“weg te gooien”
		Protection	“beschermd tegen vuil” “Het houd mijn handen schoon” “Schoon voor mijn handen” “Meer hygiëne” “Meer bescherming”
	Safety	Safe feeling	“veilig gevoel” “schoon gevoel”
Negative aspect on working with non-sterile gloves	Safety concerns	False safety	“toch deels doorlaatbaar” “doorlaatbaar dus schijnveiligheid” “schijnveiligheid zo ook voor hygiëne”
		Quality concerns	“snel kapot”
		Changing	“regelmatig moeten wisselen na handelingen”
	Problems with hands	Sweat hands	“snel vochtige handen” “zweethanden” “soms lastig aan te doen bij zweethanden”
		Tactility	“minder gevoel bij Venflon prikken”
	Environmental concerns	Environmental impact	“milieu belastend” “heel milieu belastend”
		Wasting	“onhandige verpakking” “vaak met 10 tegelijk uit de doos” “verspilling”

Appendix C: Waste collection and observation

The waste of the PICU; Children's Intensive Care Unit was collected and observed for one week. Together with fellow students from the Green Room, a report of the waste audit was created to communicate the results to the PICU department. On the following pages the report can be found.

Waste collection & observation

Observation of the waste generated by the children ICU from Erasmus MC.

Alicia Ville
Margot Honkoop
Lisanne van den Berg

Delft University of Technology, the Netherlands

Introduction

Context

The Pediatric Intensive Care Unit (PICU) from Erasmus Medical Center (Erasmus MC) has 4 areas:

1 Short stay area
2 Conventional ICU
3 Conventional ICU
4 Long stay area

Each area has its own green container where all domestic waste generated ends up. These containers are unfilled two to three times per day.

Each area counts as well with numerous hazardous waste containers. These containers waste will not be separated because of safety reasons and available time. The procedure used to unfill these containers is different than the one followed for the green containers. Adding these into the scope of the project would increase the complexity of the same to an unreachable level. Although hazardous waste will not be analysed, we will take a picture of their content to get an indication of what is in there. We will weigh them as well.

Aim

The waste of the green containers will be analysed throughout four days. Each day, one of the unit's green containers will be analysed. On the first day, we start with unit 4 and the time needed to analyse one container will be defined. If there is enough time, more than one unit can be measured per day. To differentiate the containers from each area, a sticker will be placed on the lid of each of them when positioned emptied.

Although the morning shift starts at 7:45, separating waste will start from 8:30. All trash bags will be brought throughout the day to the collection point by the workers assigned to do so. These workers are informed by Sascha and Suzan to collect the containers from the PICU. Two shifts during night, one at 10:00am. No previous separation of the waste placed in the green containers is needed.

Setup

Apparatus

- 2 garbage bins
- 3 scales
- 1 phone camera
- 3 forceps
- 1 computer
- 12 sets of protective clothes
- 1 set of plastic bags
- 1 tape (to fix the garbage bags outside)

Procedure

ICU: Children IC; WCP: Waste collection point

[ICU] Wearing protective clothes and picking up all utensils used for the waste separation.

[ICU] Taking pictures of the specific hospital waste (blue container) present in all four areas of the ICU.

Procedure per bag:

[WCP] Weighing bag

[WCP] Identifying waste per garbage bag. One to two observant(s) separate the waste using forceps. The content will be separate between the following areas. See list of subsections in excel.

- Used (Criteria: Out of packaging*)
- Unused (Criteria: Still in packaging)

[WCP] The number of gloves and syringes separated will be counted**

[WCP] Each of aforementioned area will be placed in a different garbage bag (8 bags).

[WCP] Each bag will be weighed at the end of the day or when filled.

[WCP] Weighed garbage bags will be placed back in the containers.

* We will only consider this criterion when separating between used or unused as the circumstances does not allow us to be accompanied by an PICU worker that could give us more insights.
** The second observant would also proceed to take photos along the day and complete the excel file.

Results

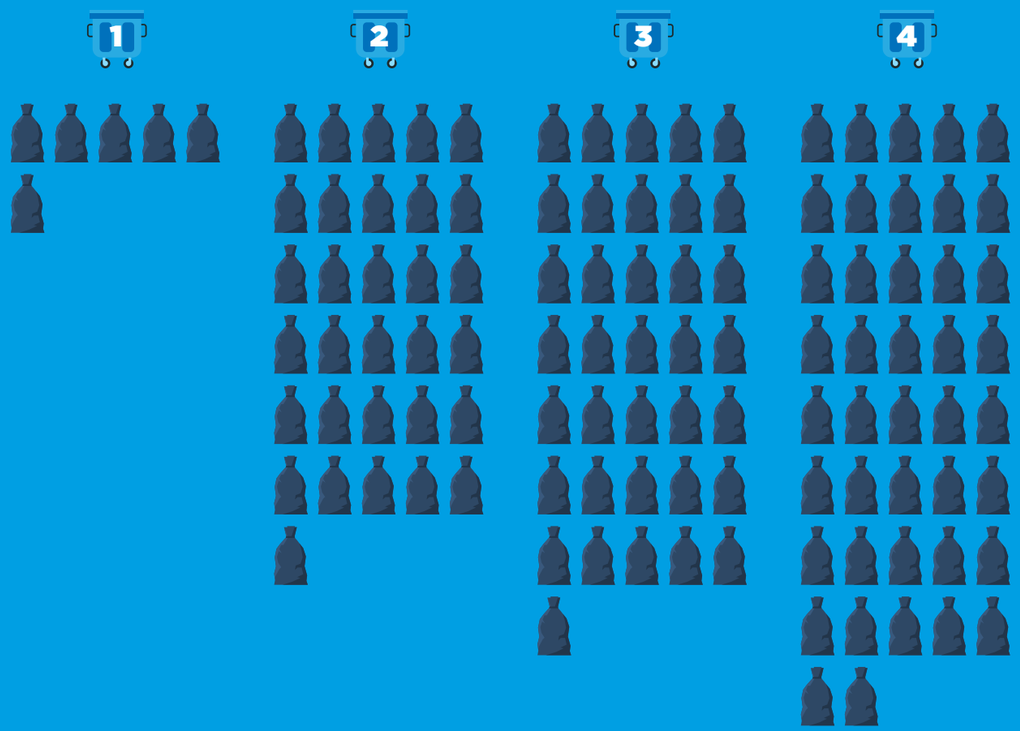


Figure 1. Trash bags per day per unit of the PICU

NB: For Unit 1, the bags might correspond to a longer period of time of between 2 to 4 days.

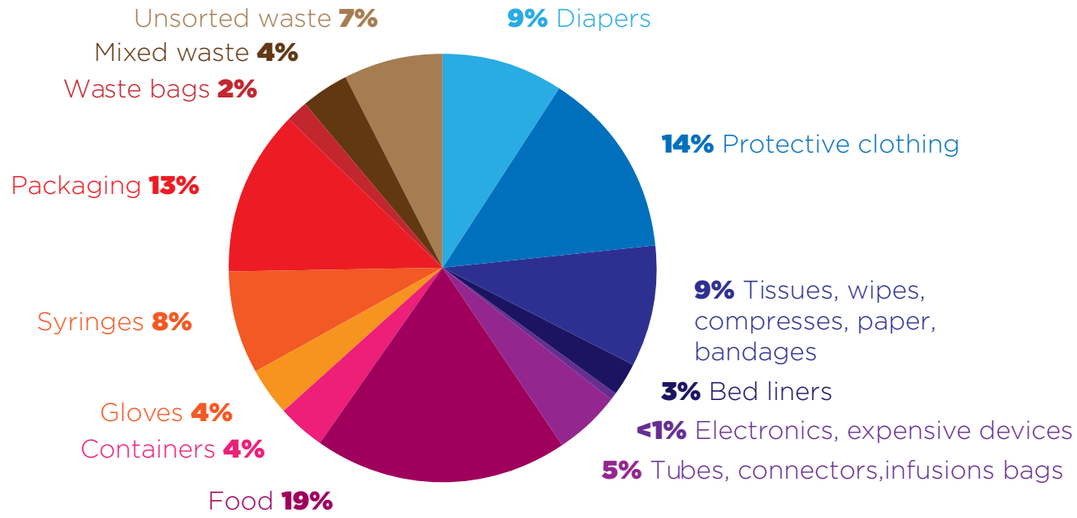


Figure 2. Waste percentages per typology

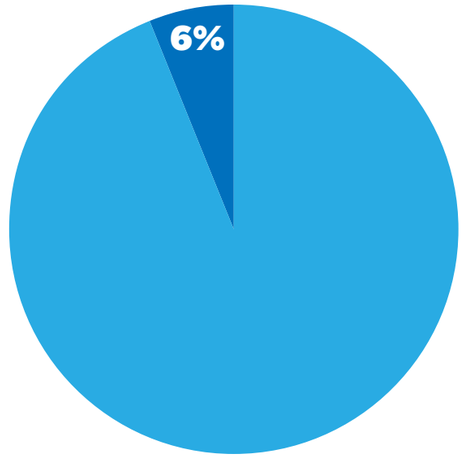
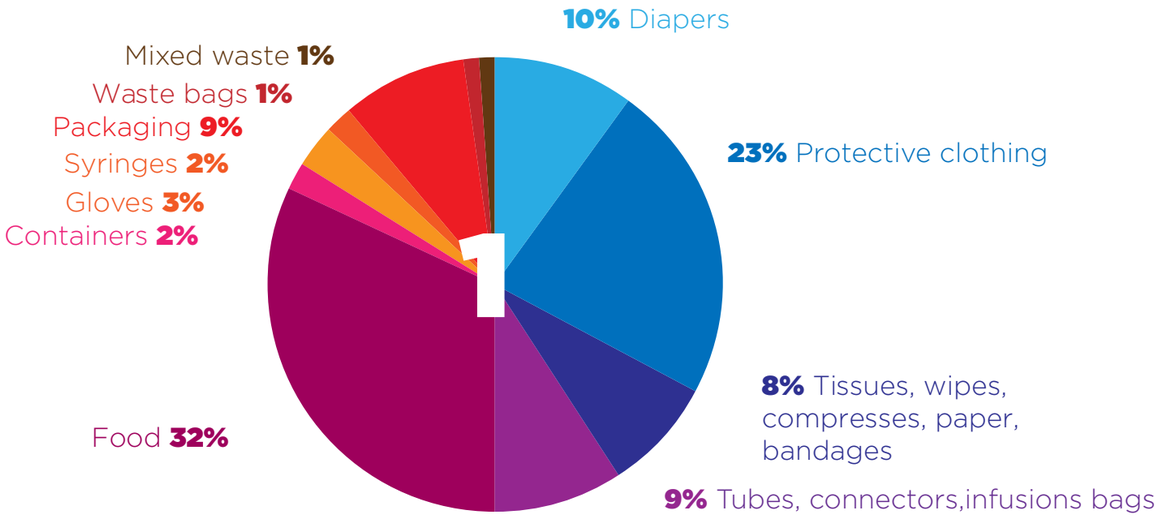
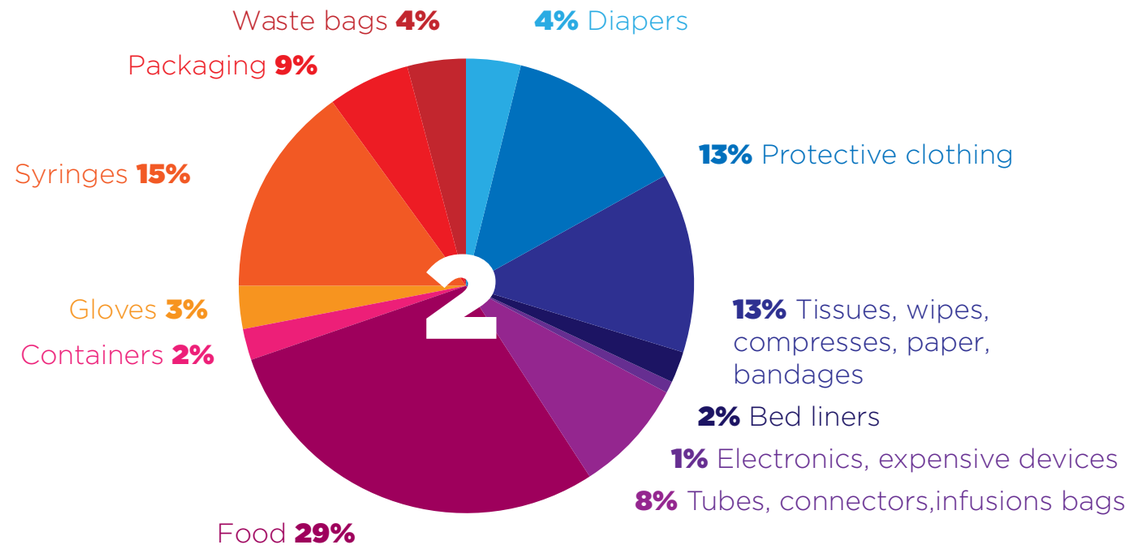


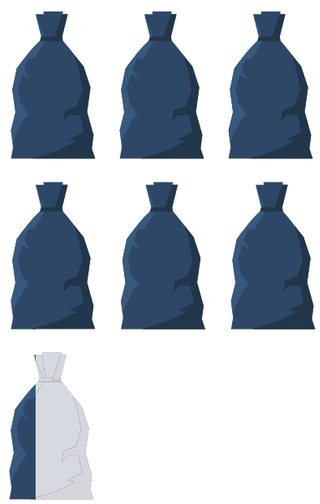
Figure 2. Unused waste percentages from the quantified items

Per unit



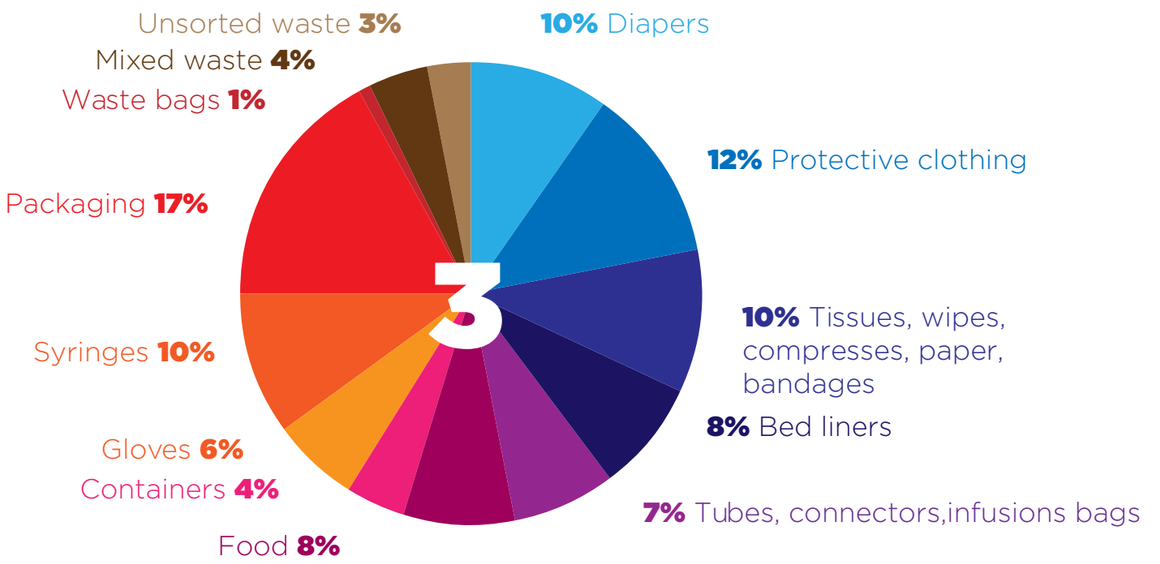


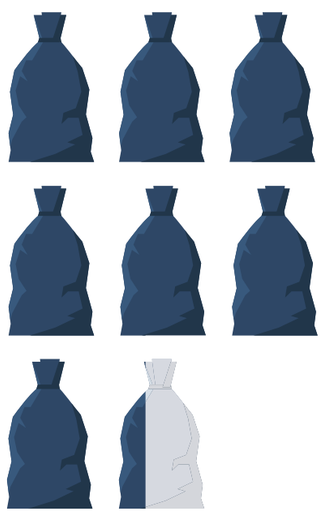
0,6 trash bags per person per day



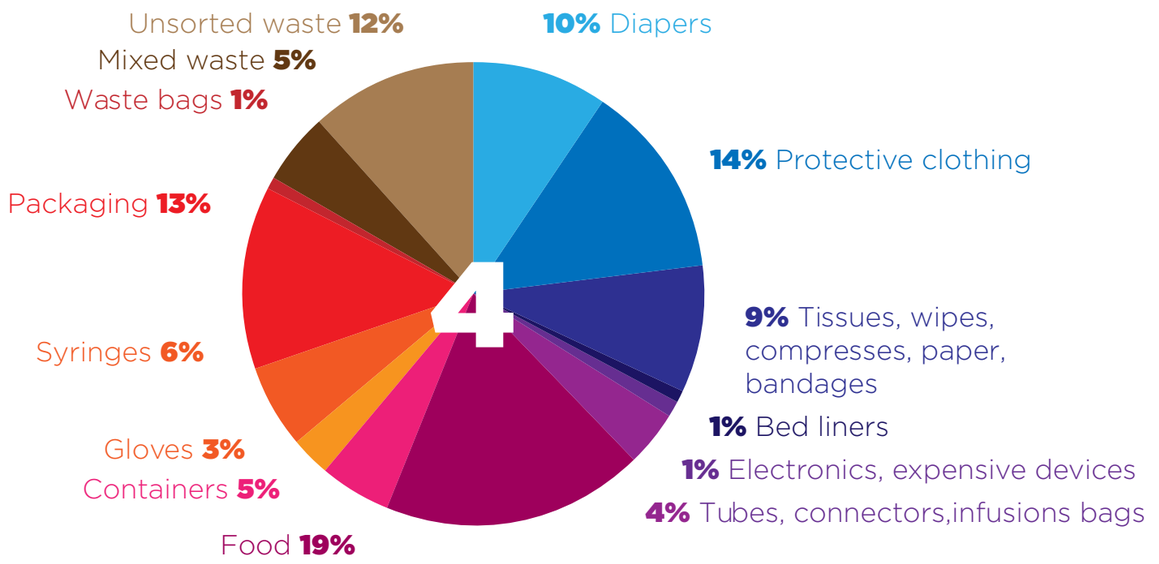
6,2 trash bags per person per day

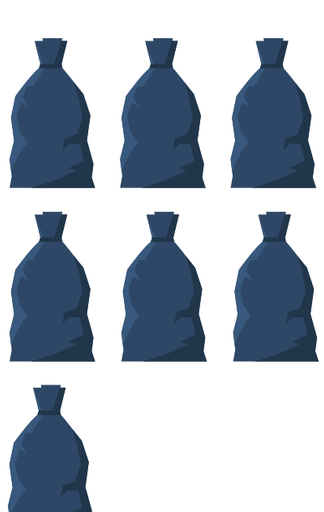
Per unit





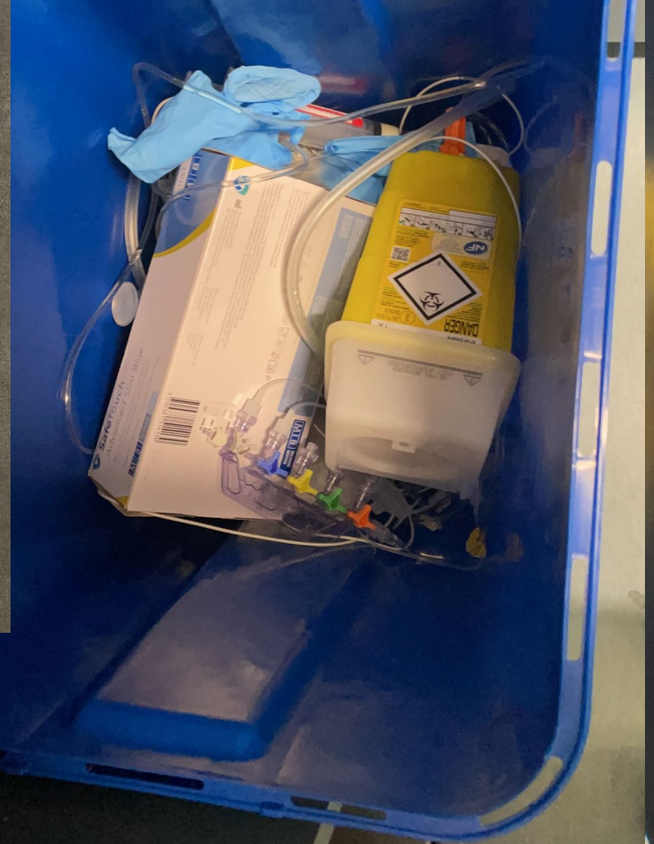
7,2 trash bags per person per day





7 trash bags per person per day


TOT HIER HOOGTE OPSLAG




OPSLAG PLASTI


OPSLAG PLASTIC BAKKEN
OPSLAG PLASTI

Observations & Recommendations

Limitations study

- Some trash bags contained infectious materials, like blood. Due to the potential danger that this could generate to open such bags, they were consider as unsorted waste.

- A high number of syringes were found with the tubing still connected. As all syringes in this status contained some remaining liquid on the interior, the tubes were not separated, thus counted as syringe-related waste.

- First day weight result resulted slightly unprecise. Although the weighting method was corrected for the following days, these might results on some overall unprecise numbers.

- For some products it was difficult to distinquish whether they were used or unsused: gloves, syringes, some loose tubes. If there was doubt, the products were placed in the used category.

General observations

- The waste generated at area 1 is considerably less than in the other areas of the PICU.

- Gloves were found sometimes filled with liquid, therefore considered as mized waste.

- We could recognize as a pattern that some containers contained a bag we suppose came from the farmacy. This deduction was done as the bag contained mostly packaging from syringes and medication. Here, syringes and tubes are not normally present together but separated.

- Some of the waste found in the green container seemed to be products which should have been disposed differently:

A blanket was found, a supposition was done that this product could have been thrown with liners. Syringes containing blood, glass and needles which seemed hazardous were also found in the green container, although their condition seemed to indicate they should be treated as hazardous waste.

- Waste typologies come highly mixed in some bags. Food related waste can be found in trash bags next to syringes and intubation devices.

Unused devices observations

- The syringes that were thrown away unused were in the mayority containing a medication which had expired. This was not the case for the rest of the unused waste.

- Some baby food containers were found still mostly full in the containers.

- There was a high amount of unused tissues present, but all of them were out of their packages.

- From the unused waste, most is connectors Packed connectors were found in several occasions.

Recommendations

- Staff working at the PICU could be reinstruct about waste separation: This would ensure that all wastestreams are correctly separated.

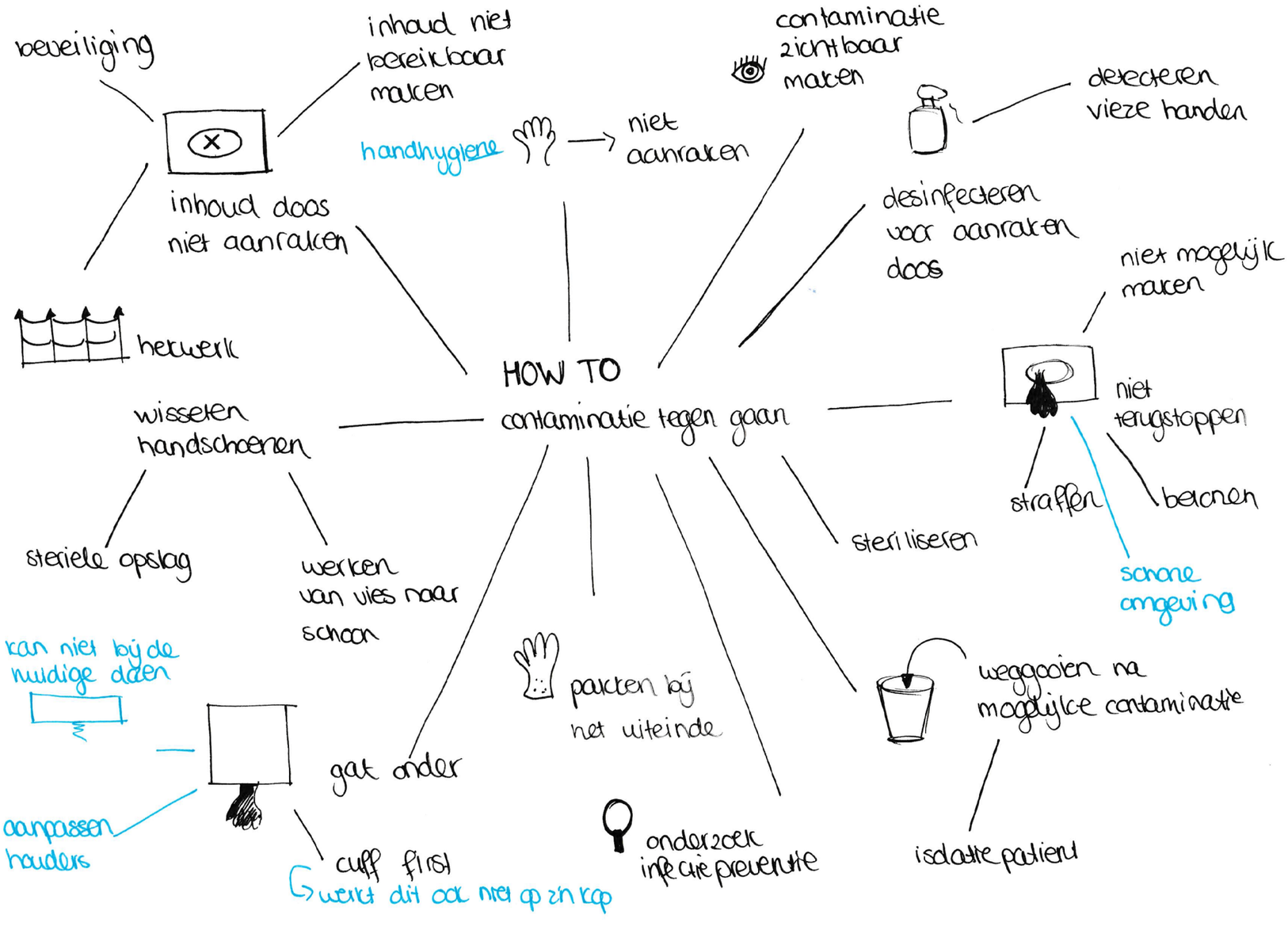
- Protective clothing resulted on a big amount of the waste, reusable alternatives could be analysed.

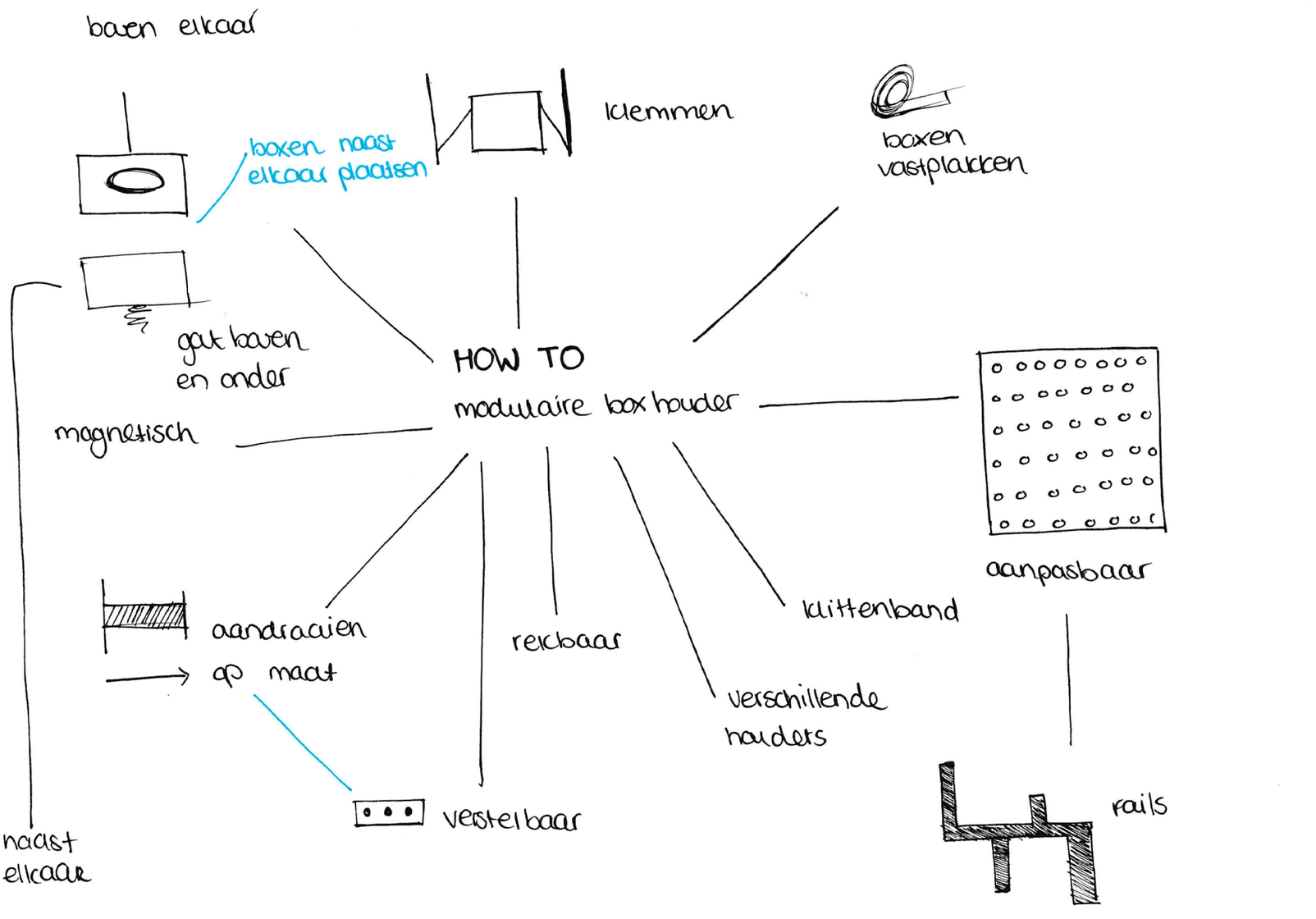
- Unit 4 had the biggest amount of waste, studies could be undertaken to understand why is this happening and how to tackle it.

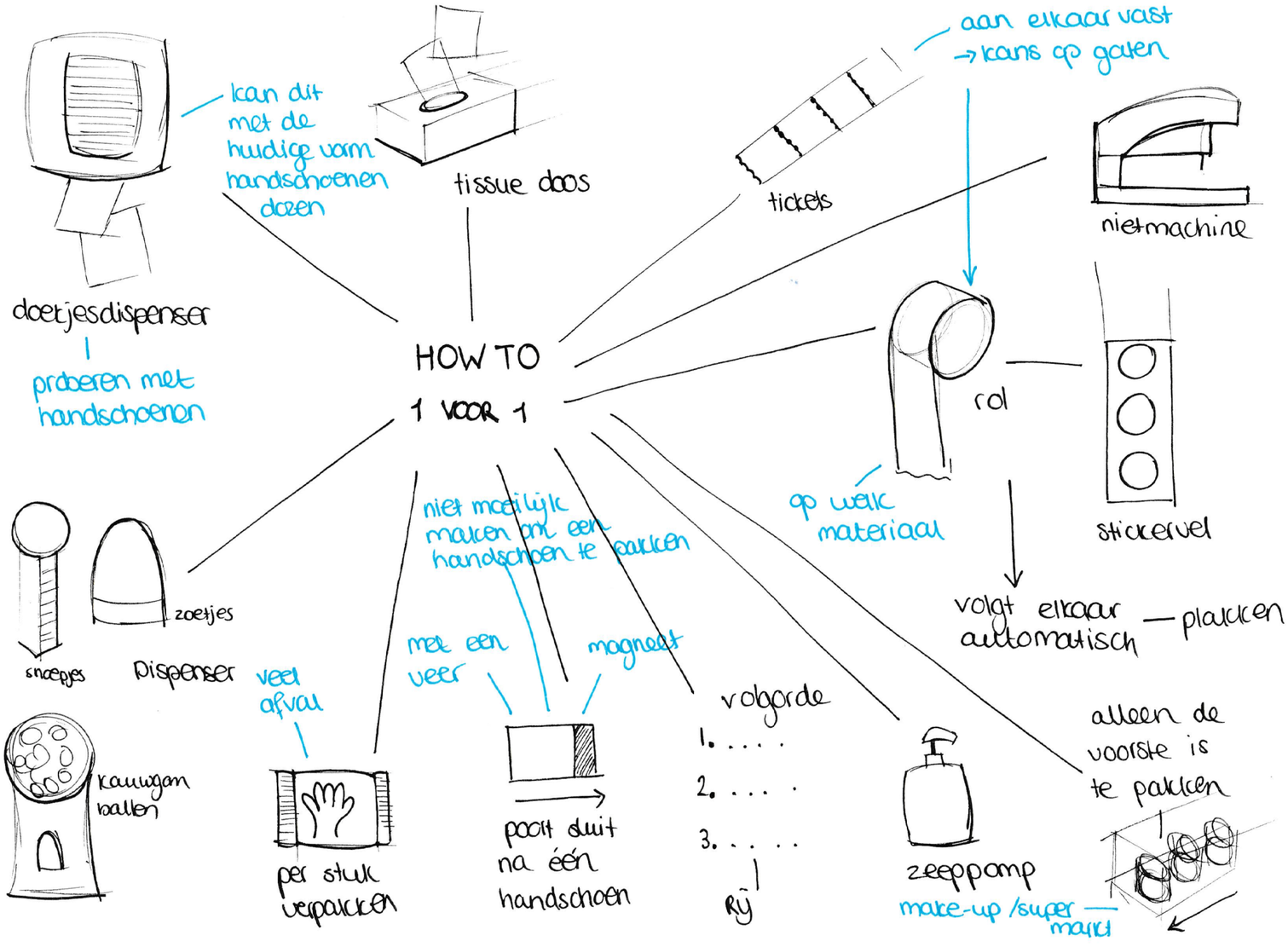
- Food was the biggest amount of waste, which was non hazardous but mixed with the rest. A separation of food waste from the hospital waste could be an alternative to look into

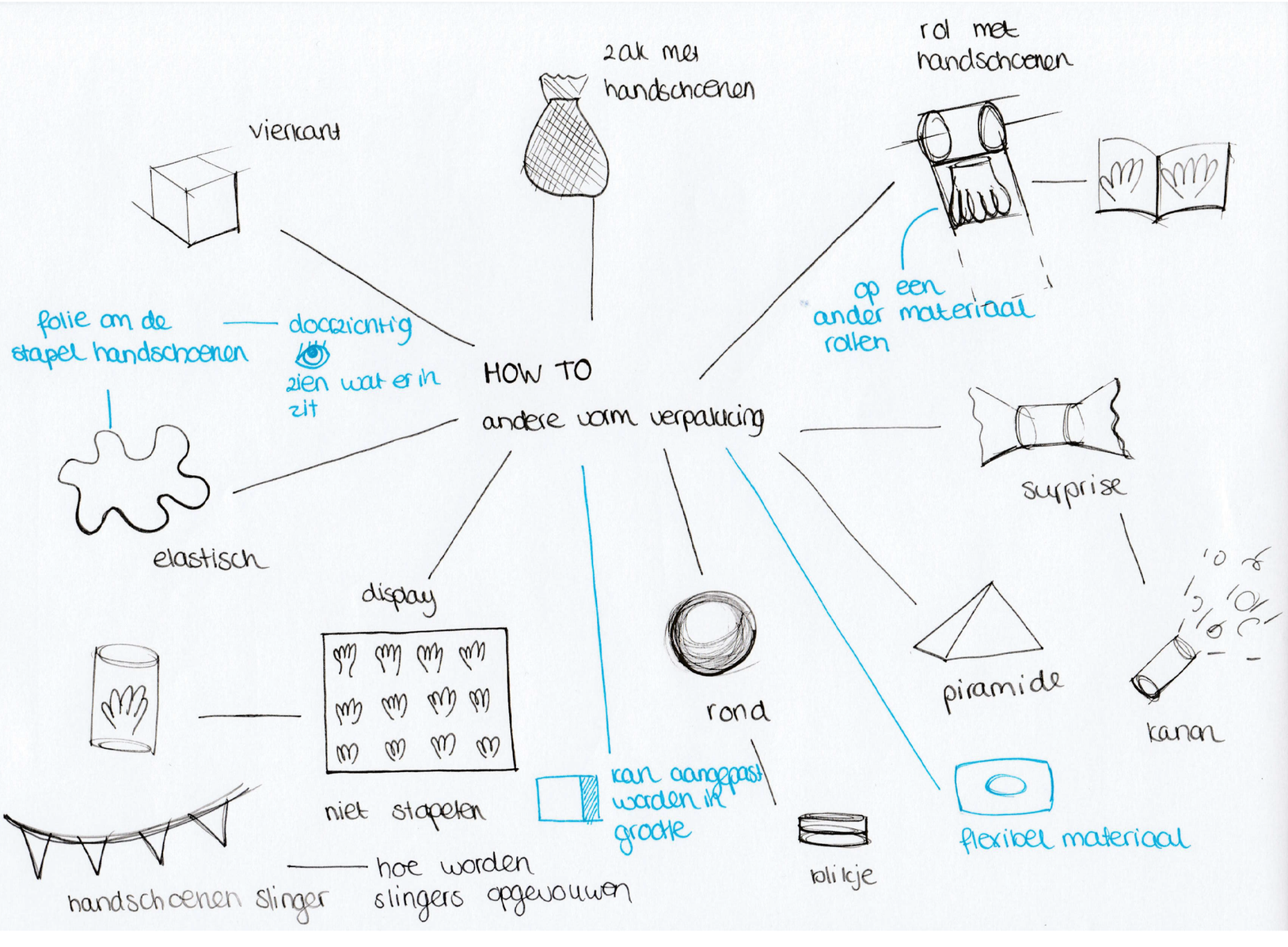
- Implementation of reusable hot water bags instead of filling gloves with hot water.

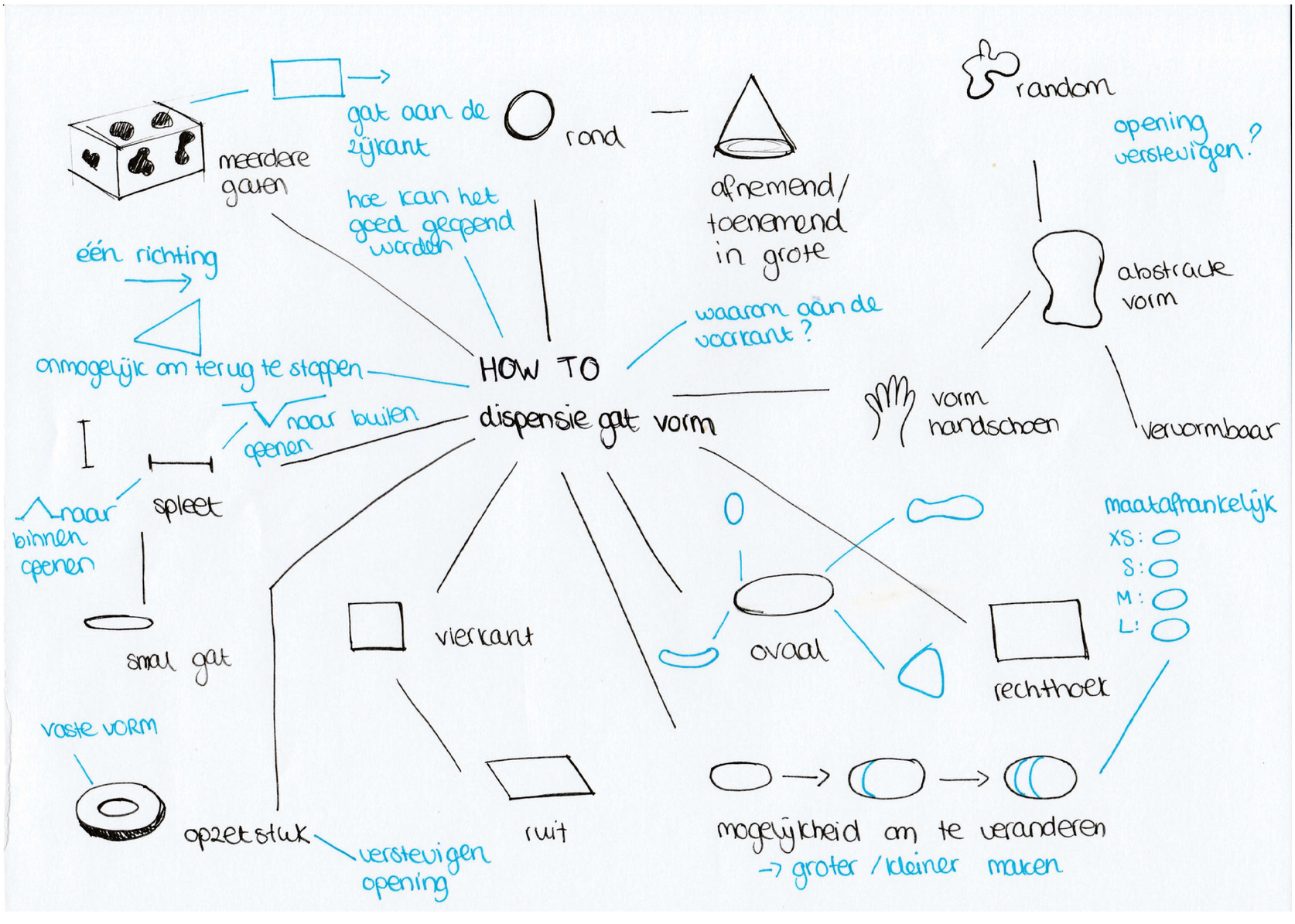
Appendix D: Ideation

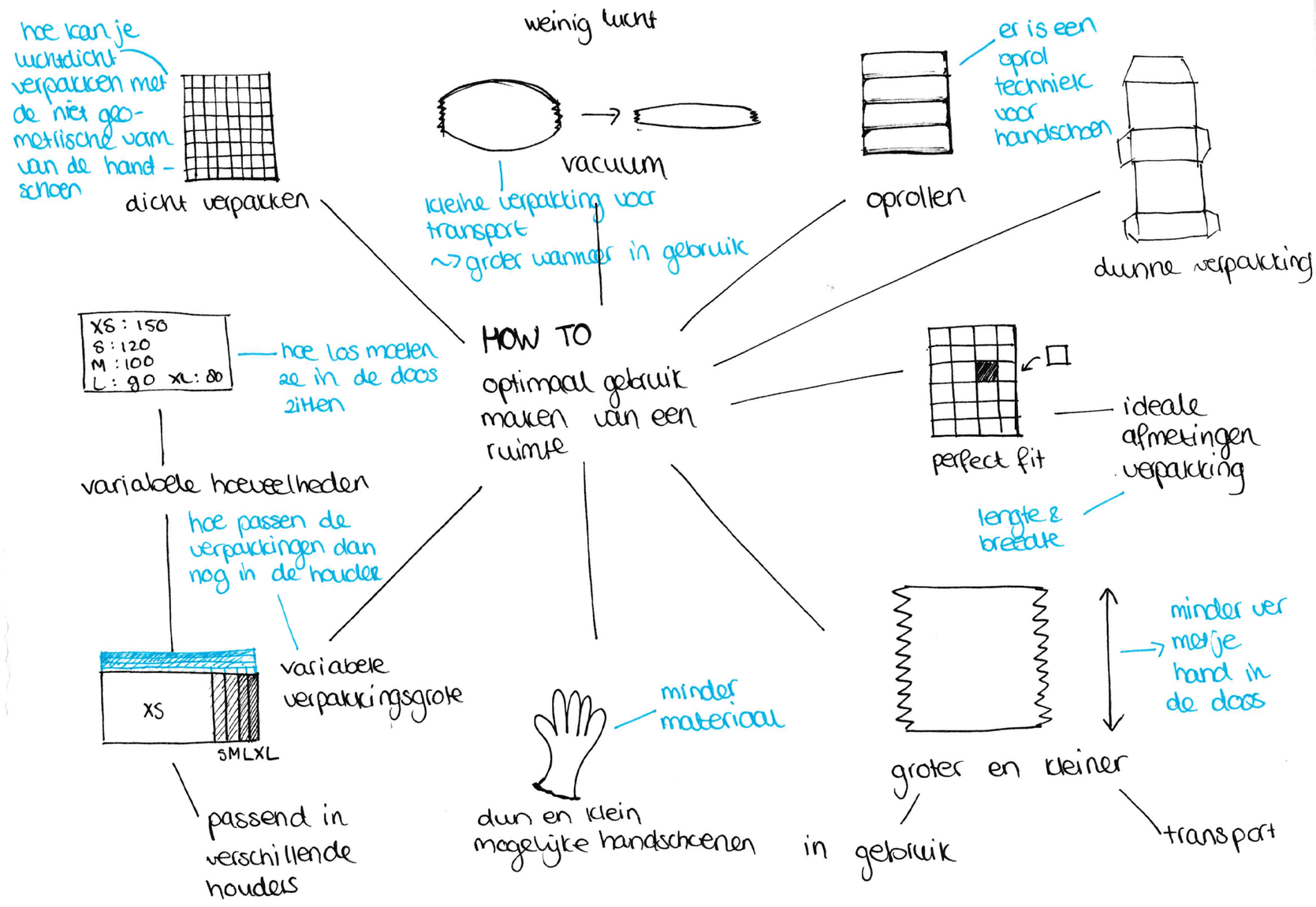

HOW TO
contaminatie tegen gaan
beveiliging
inhoud niet bereikbaar maken
inhoud doos niet aanraken
herwerk
handhygiene
niet aanraken
contaminatie zichtbaar maken
detecteren vieze handen
desinfecteren voor aanraken doos
niet mogelijk maken
niet terugstoppen
strapfen
bekneden
schone omgeving
wisselen handschoenen
steriele opslag
werken van vies naar schoon
steriliseren
kan niet bij de huidige deuren
aanpassen houders
gat onder
cuff first
werkt dit ook niet op zn kop
parken bij het uiteinde
onderzoek infectie preventie
weggooien na mogelijke contaminatie
isolatie patient

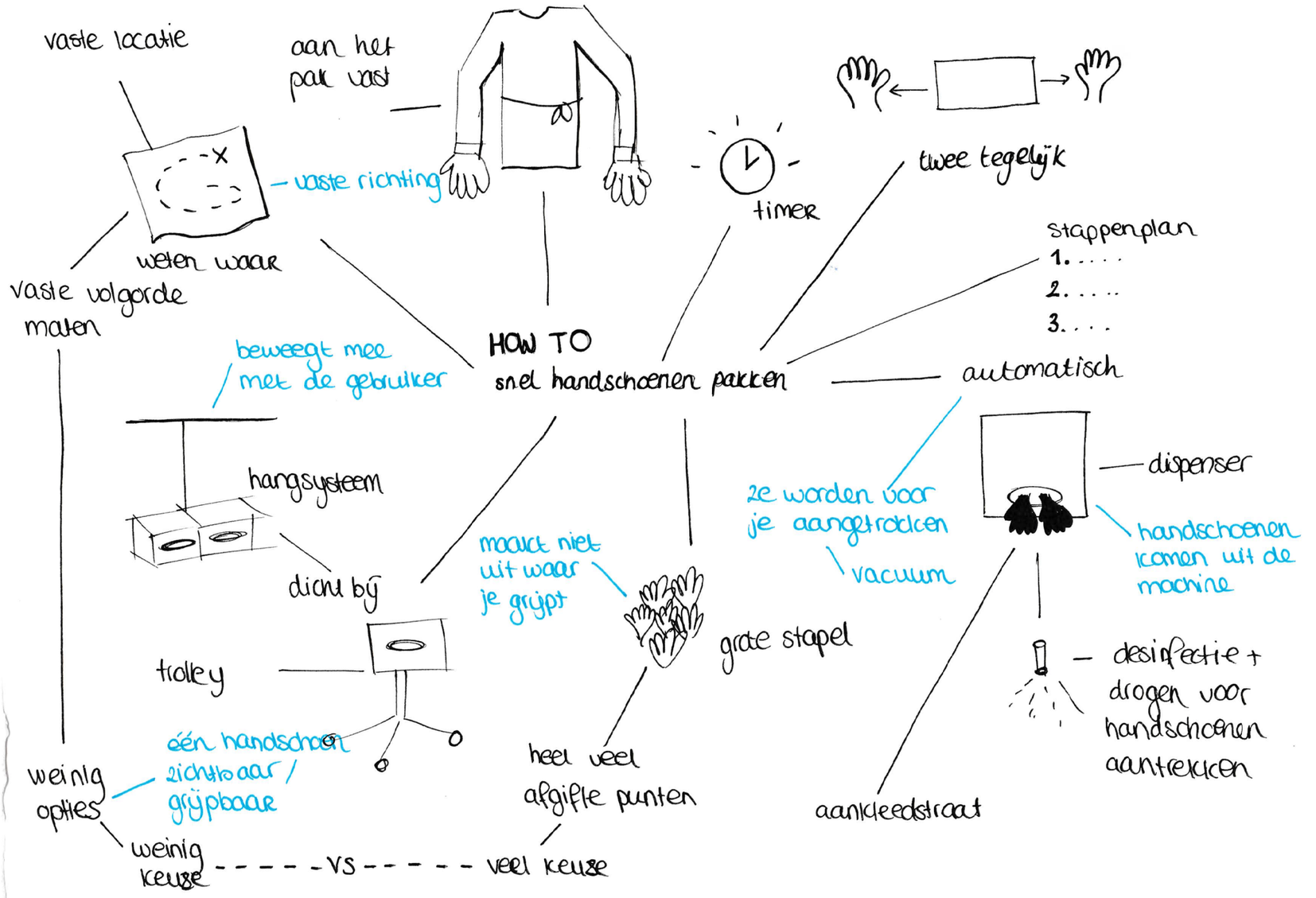

HOW TO
modulaire box houder
boven elkaar
boxen naast elkaar plaatsen
klemmen
boxen vastplakken
gat boven en onder
magnetisch
aandraaien
op maat
reikbaar
klittenband
verschillende houders
aanpasbaar
verstelbaar
rails
naast elkaar

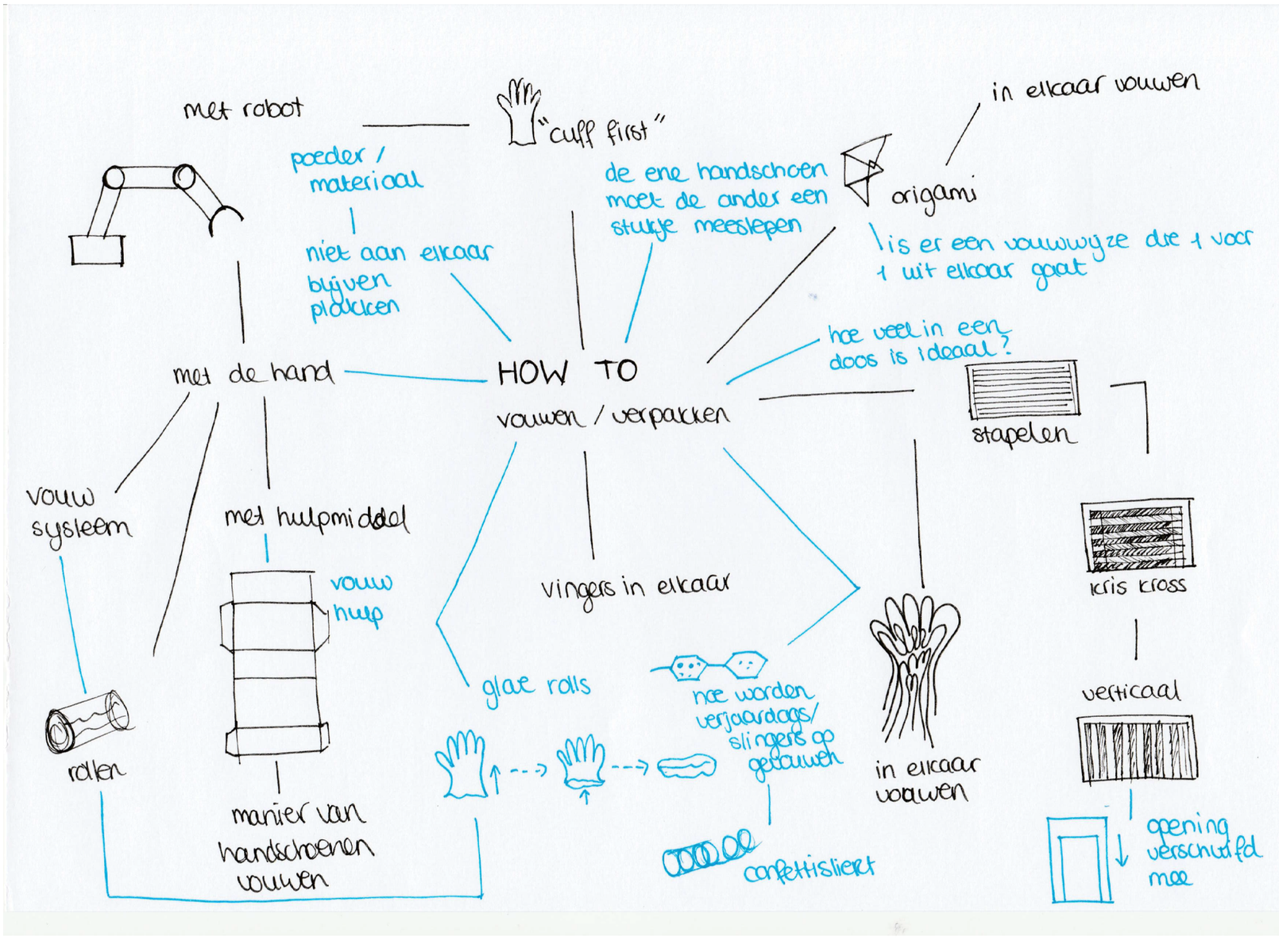

HOW TO
1 VOOR 1
doetjesdispenser
proberen met handschoenen
kan dit met de huidige vorm handschoenen dozen
tissue doos
tickets
aan elkaar vast → kans op gaten
niet machine
rol
op welk materiaal
stickervel
volgt elkaar automatisch — plakken
snoepjes
Dispenser
zoetjes
niet moeilijk maken om een handschoen te pakken
met een veer
magneet
veel afval
per stuk verpakken
kauwgom ballen
pakt duit na één handschoen
volgorde
1. . . .
2. . . .
3. . . .
rij
zeeppomp
make-up / supermarkt
alleen de voorste is te pakken

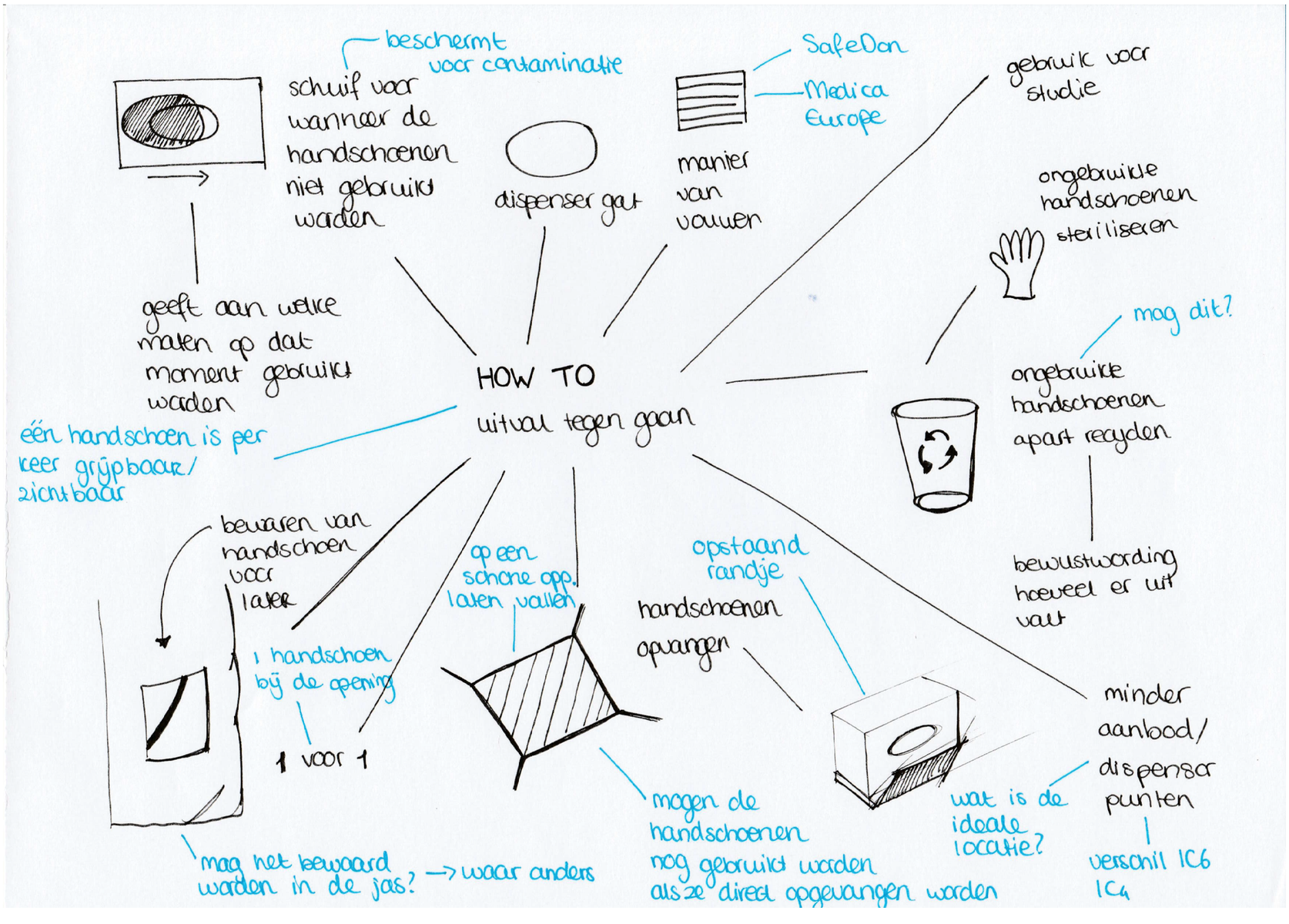

HOW TO
andere vorm verpakking
vierkant
zak met handschoenen
rol met handschoenen
op een ander materiaal rollen
folie om de stapel handschoenen
doorzichtig
zien wat er in zit
elastisch
surprise
display
niet stapelen
rond
piramide
kanon
kan aangepast worden in grootte
flexibel materiaal
rolletje
handschoenen slinger
hoe worden slingers opgevouwen

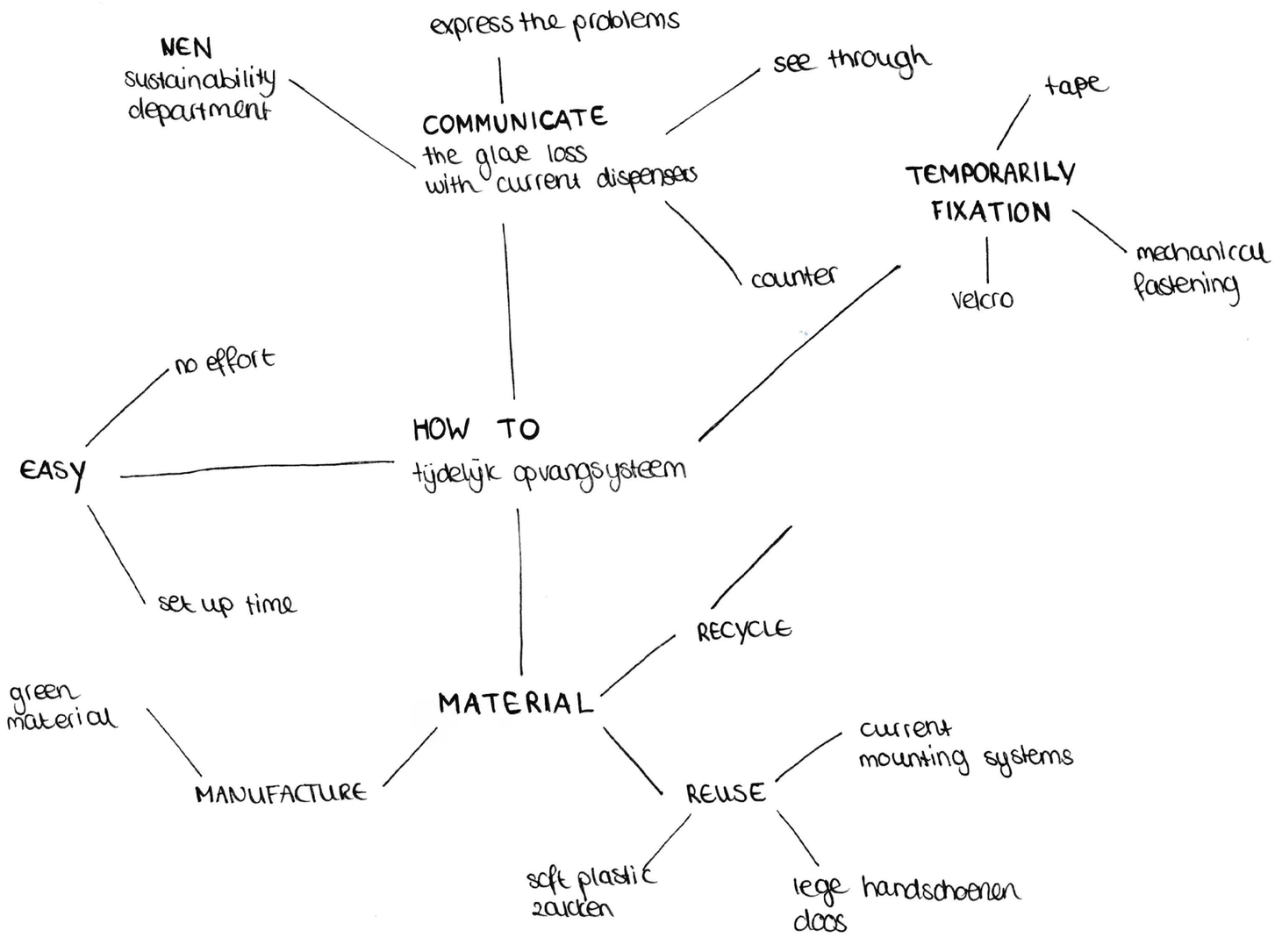

HOW TO
dispensie gat vorm
meerdere gaten
gat aan de zijkant
hoe kan het goed gespend worden
rond
afnemend/ toenemend in grote
random
opening verstevigen?
abstracte vorm
vervormbaar
vorm handschoen
waarom aan de voorkant?
één richting
onmogelijk om terug te stoppen
naar buiten openen
naar binnen openen
spleet
smal gat
vierkant
ovaal
rechthoek
maatafhankelijk
XS:
S:
M:
L:
vaste vorm
opzetstuk
verstevigen opening
ruit
mogelijkheid om te veranderen
-> groter / kleiner maken

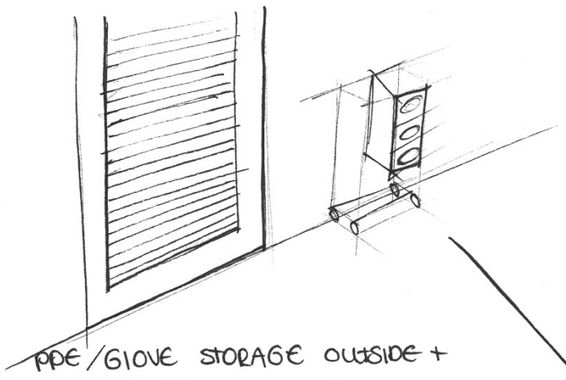

HOW TO
optimaal gebruik maken van een ruimte
hoe kan je waterdicht verpakken met de niet geometrische vorm van de handschoen
dicht verpakken
weinig lucht
vacuum
kleine verpakking voor transport
~> groter wanneer in gebruik
oprollen
er is een oprol techniek voor handschoen
dunne verpakking
XS : 150
S : 120
M : 100
L : 90 XL: 80
hoe los moeten ze in de doos zitten
variabele hoeveelheden
hoe passen de verpakkingen dan nog in de houder
variabele verpakkingsgrote
XS
SMLXL
passend in verschillende houders
perfect fit
ideale afmetingen verpakking
lengte & breedte
minder materiaal
dun en klein mogelijke handschoenen in gebruik
minder ver moeten hand in de doos
groter en kleiner
transport


HOW TO
snel handschoenen pakken
vaste locatie
weten waar
vaste richting
aan het pak vast
vaste volgorde maten
beweegt mee met de gebruiker
hangsysteem
dicht bij
trolley
één handschoen zichtbaar / grijpbaar
weinig opties
weinig keuze
----- vs -----
veel keuze
maakt niet uit waar je grijpt
heel veel afgifte punten
grote stapel
timer
twee tegelijk
stappenplan
1. . . .
2. . . .
3. . . .
automatisch
ze worden voor je aangetrokken
vacuum
dispenser
handschoenen komen uit de machine
desinfectie + drogen voor handschoenen aantrekken
aankleedstraat


HOW TO
vouwen / verpakken
met robot
"cuff first"
poeder / materiaal
niet aan elkaar blijven plakken
de ene handschoen moet de ander een stukje meeslepen
origami
in elkaar vouwen
is er een vouwwijze die 1 voor 1 uit elkaar gaat
met de hand
vouw systeem
rollen
met hulpmiddel
vouw hulp
manier van handschoenen vouwen
vingers in elkaar
glad rolls
hoe worden verjaardags/ slingers op getouwen
confettisliert
in elkaar vouwen
hoe veel in een doos is ideaal?
stapelen
kris kross
verticaal
opening verschuift mee


HOW TO
uitval tegen gaan
beschermt voor contaminatie
schuif voor wanneer de handschoenen niet gebruikt worden
geeft aan welke maten op dat moment gebruikt worden
dispenser gat
SafeDon
Medica Europe
manier van vullen
gebruik voor studie
ongebruikte handschoenen steriliseren
mag dit?
ongebruikte handschoenen apart reyden
bewustwording hoeveel er uit valt
één handschoen is per keer grijpbaar/ zichtbaar
bewaren van handschoen voor later
1 handschoen bij de opening
1 voor 1
op een schone opp. laten vallen
opstaand randje
handschoenen opvangen
minder aanbod/ dispensor punten
verschil IC6 IC4
wat is de ideale locatie?
mag het bewaard worden in de jas? → waar anders
mogen de handschoenen nog gebruikt worden als ze direct opgevangen worden


express the problems
NEN
sustainability department
COMMUNICATE
the glue loss with current dispensers
see through
tape
TEMPORARILY FIXATION
counter
velcro
mechanical fastening
no effort
HOW TO
tijdelijk opvangsysteem
EASY
set up time
RECYCLE
green material
MATERIAL
MANUFACTURE
current mounting systems
REUSE
soft plastic zakken
lege handschoenen doos



PPE / GLOVE STORAGE OUTSIDE + INSIDE THE IC ROOM

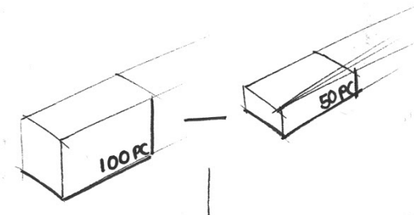
WHY is the ICU room stocked with PPE if the patient is in isolation

ONLY store the PPE in the infection "pre-room"

TAKE an extra glove with you

HOW TO

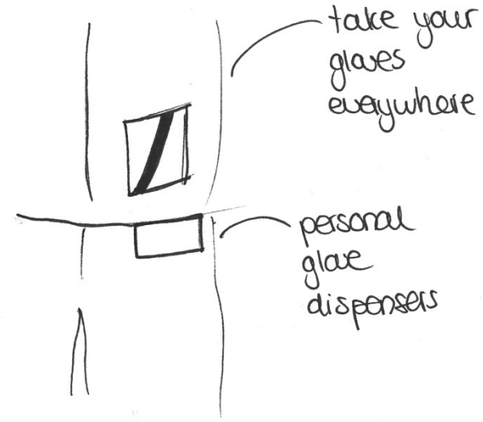
less unused glaves by throwing away after isolation patient leaves



PACKAGING SIZE

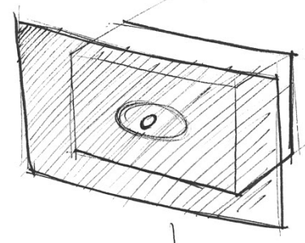
ERGONOMICS

base storage / stocking on ergonomics data

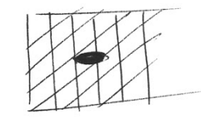


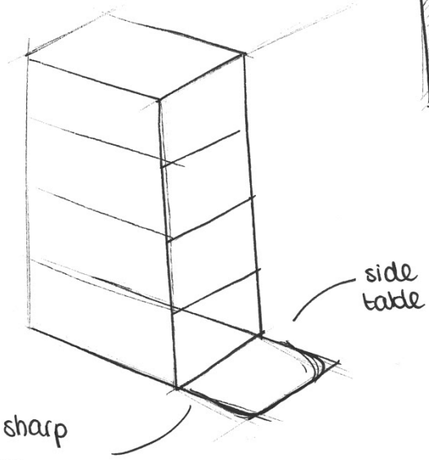
take your glaves everywhere

personal glave dispensers



catch before use



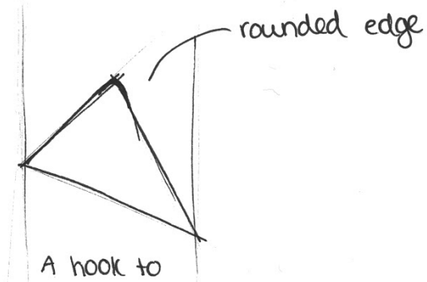


side table

no sharp edges

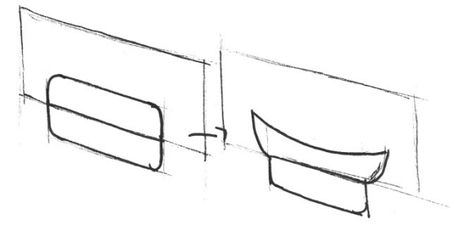
HOW to

catch and store the "unintended" glaves

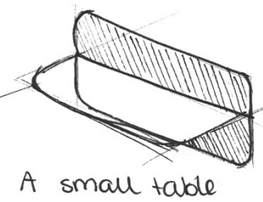


rounded edge

A hook to put the glaves on



take with you



A small table

also indicate which sizes are used

TECHNOLOGY

help patient through using technology

being able to turn on the TV / radio

open storages

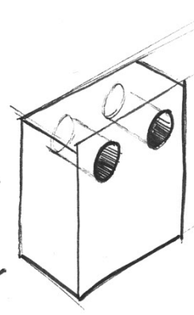
HOW TO

alternatief voor handschoenendoos

USED IN GREENHOUSES AND FABRICS

TICKET

going through the cleaning street allows you to enter



VACUUM

automatic dispenser

TWO STEPS

1. desinfection
2. drying
3. putting glave on

WASHABLE GLOVES

personal items

washed together with the uniforms

ALTERNATIVE FOR GLOVES

STERALIZE AND REUSE MATERIAL

device also removes the layer

personalised fit

automatic dispenser

"spray tan device"

sprays a protective layer on the hands

FEELS MORE PERSONAL to patient

ONLY SPRAY PROTECTION ON WOUNDS

express the problems

NEN

sustainability department

COMMUNICATE

the glave loss with current dispensers

see through

counter

TEMPORARILY FIXATION

tape

Velcro

mechanical fastening

HOW TO

tijdelijk opvangsysteem

EASY

no effort

set up time

MATERIAL

RECYCLE

green material

MANUFACTURE

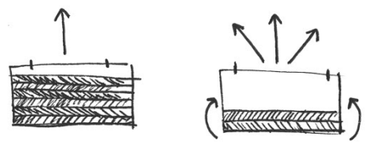
REUSE

current mounting systems

soft plastic zakken

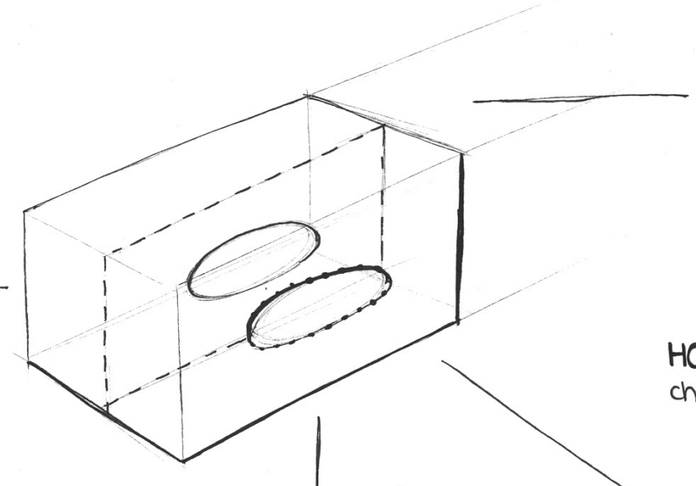
lege handschoenen doos

PROBLEM:
the glaves at the bottom stick to eachother and come out together.
The glaves are able to move in multiple directions



the glaves are held back by the packaging in the beginning

GLOVE BOX
DISPENSER } design

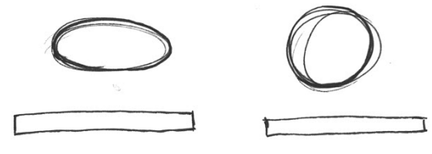


box with an extra opening shield in the middle

packaging of 50 pieces
|
more cardboard

HOW TO
change the shape of the opening

change the shape of the opening during use



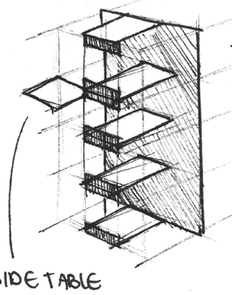
WHAT IS:
the ideal opening shape

to reduce the ~~dimension~~ freedom to move

WHAT IS
the ideal restriction/freedom of movement

being able to reduce the volume of the box during use
|
HOW TO: make one half of the box flat

PLATE IN FRONT OF THE OPENING

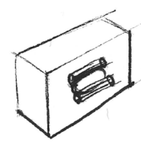


PLACE THE MOUNTING SYSTEM IN A DIFFERENT PLACE

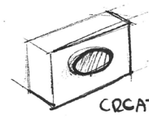
SIDE TABLE
WHAT IS THE OPTIMAL SHAPE

ADDITIONS TO THE CURRENT SITUATION

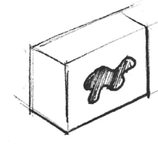
~~VERTICAL~~ DISPENSE SYSTEM
HORIZONTAL



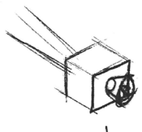
TWO RUBBER ROLLS IN FRONT OF THE OPENING



CREATE A TEST SET-UP

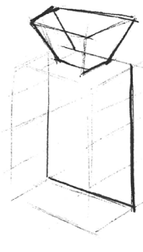


CHANGE THE SHAPE OF THE OPENING



COLLECT DATA

RULES AND REGULATIONS



SCALE ON TOP OF THE WALL MOUNT

ADJUST THE CURRENT SITUATION

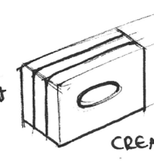
DISPENSE DIRECTION, STACKING, DISPENSE SYSTEM

OPENING HAS STEPS — TRANSFORM THE SHAPE DURING USE

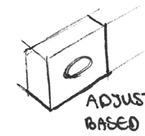
FOLD GLOVES PER PAIR

FOLDABLE BOX

MATERIAL ADJUSTMENT

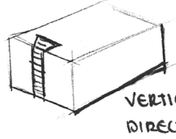


CREATE INTERMEDIATE STEPS



ADJUST QUANTITY BASED ON ERGONOMICS

LIMIT THE FREEDOM OF MOVEMENT

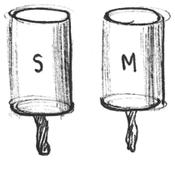


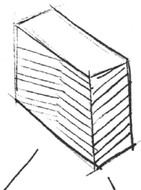
PICK FROM THE TOP

VERTICAL DISPENSE DIRECTIONS

PUSH THE GLOVES TO THE FRONT

CREATE A NEW SITUATION

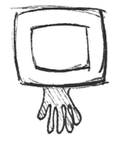




NEW FOLDING PATTERN

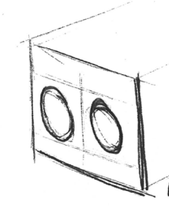
MANUALLY

AUTOMATIC

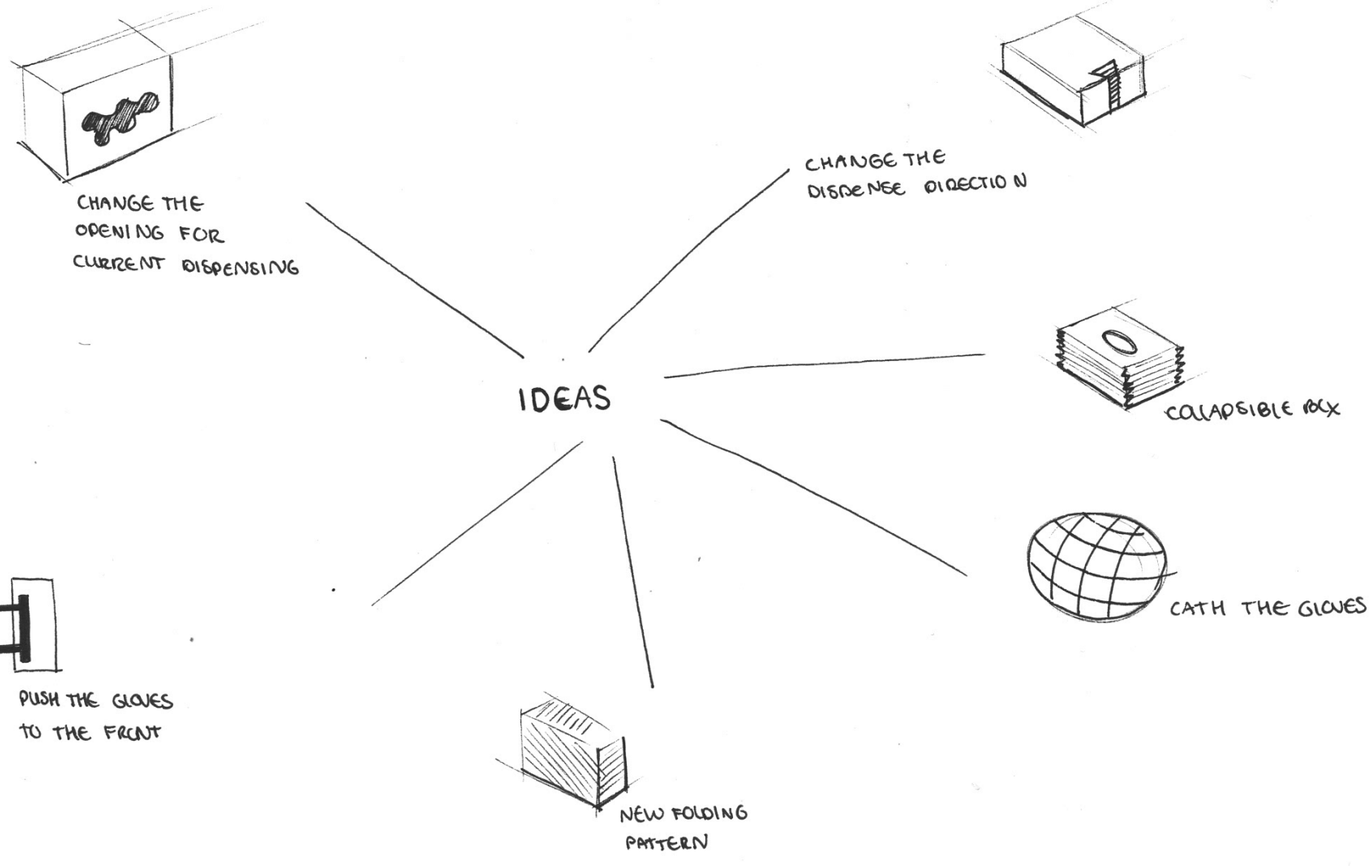


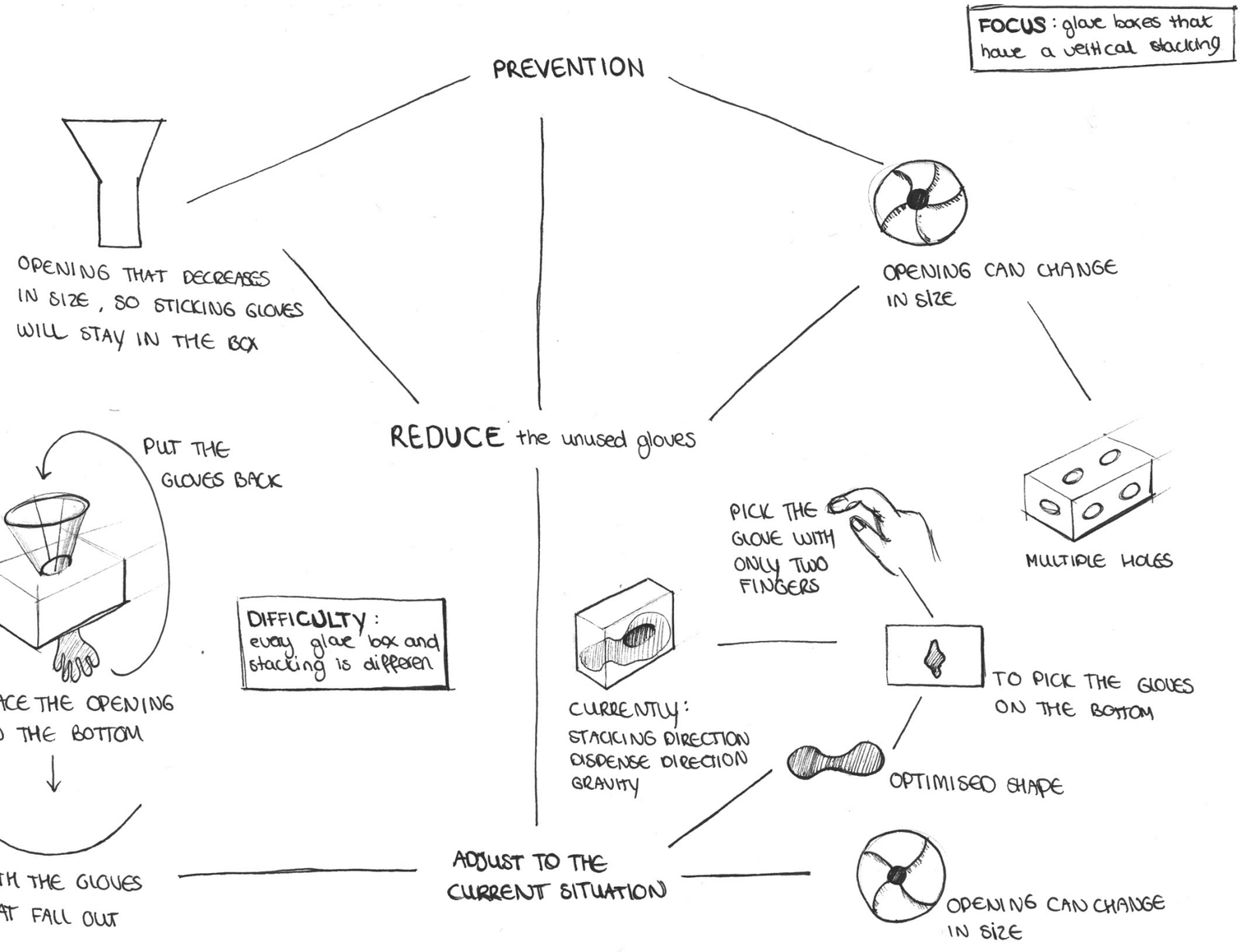
AUTOMATIC DISPENSER — ELECTRONIC / HUMAN POWER

MELT GLOVE AROUND HAND



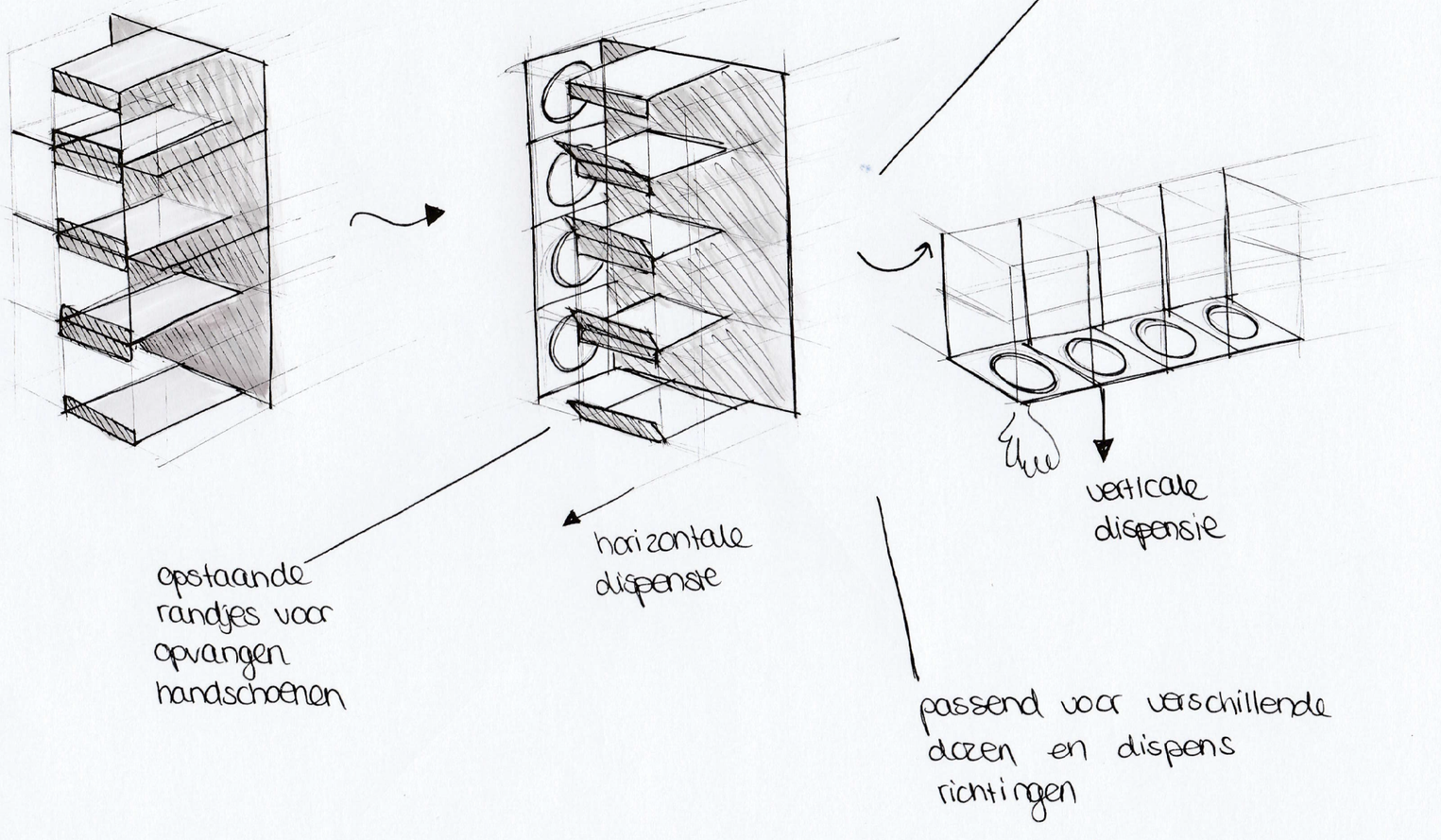
AUTOMATIC DON GLOVES


CHANGE THE OPENING FOR CURRENT DISPENSING
CHANGE THE DISPENSE DIRECTION
IDEAS
COLLAPSIBLE BOX
CATH THE GLOVES
PUSH THE GLOVES TO THE FRONT
NEW FOLDING PATTERN


FOCUS : glove boxes that have a vertical stacking
PREVENTION
OPENING THAT DECREASES IN SIZE , SO STICKING GLOVES WILL STAY IN THE BOX
OPENING CAN CHANGE IN SIZE
REDUCE the unused gloves
PUT THE GLOVES BACK
PLACE THE OPENING ON THE BOTTOM
CATH THE GLOVES THAT FALL OUT
DIFFICULTY : every glove box and stacking is different
PICK THE GLOVE WITH ONLY TWO FINGERS
MULTIPLE HOLES
CURRENTLY : STACKING DIRECTION DISPENSE DIRECTION GRAVITY
TO PICK THE GLOVES ON THE BOTTOM
OPTIMISED SHAPE
ADJUST TO THE CURRENT SITUATION
OPENING CAN CHANGE IN SIZE

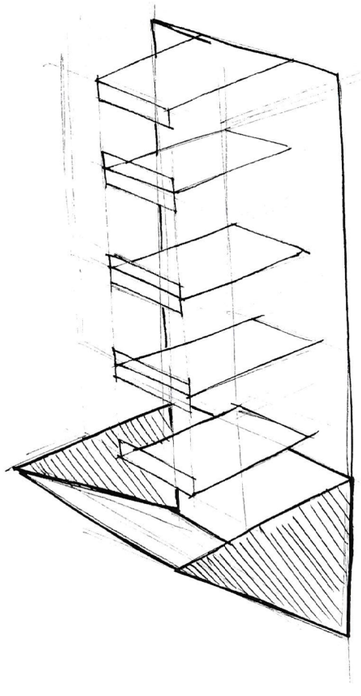
IDEA 1

Adapt the current dispense systems



IDEA 2

catch the glaves

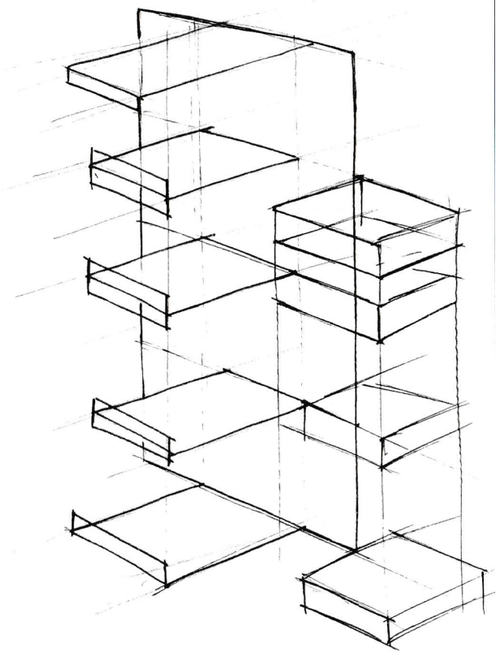


how to distinquish the sizes

act to communicate the number of unused glaves

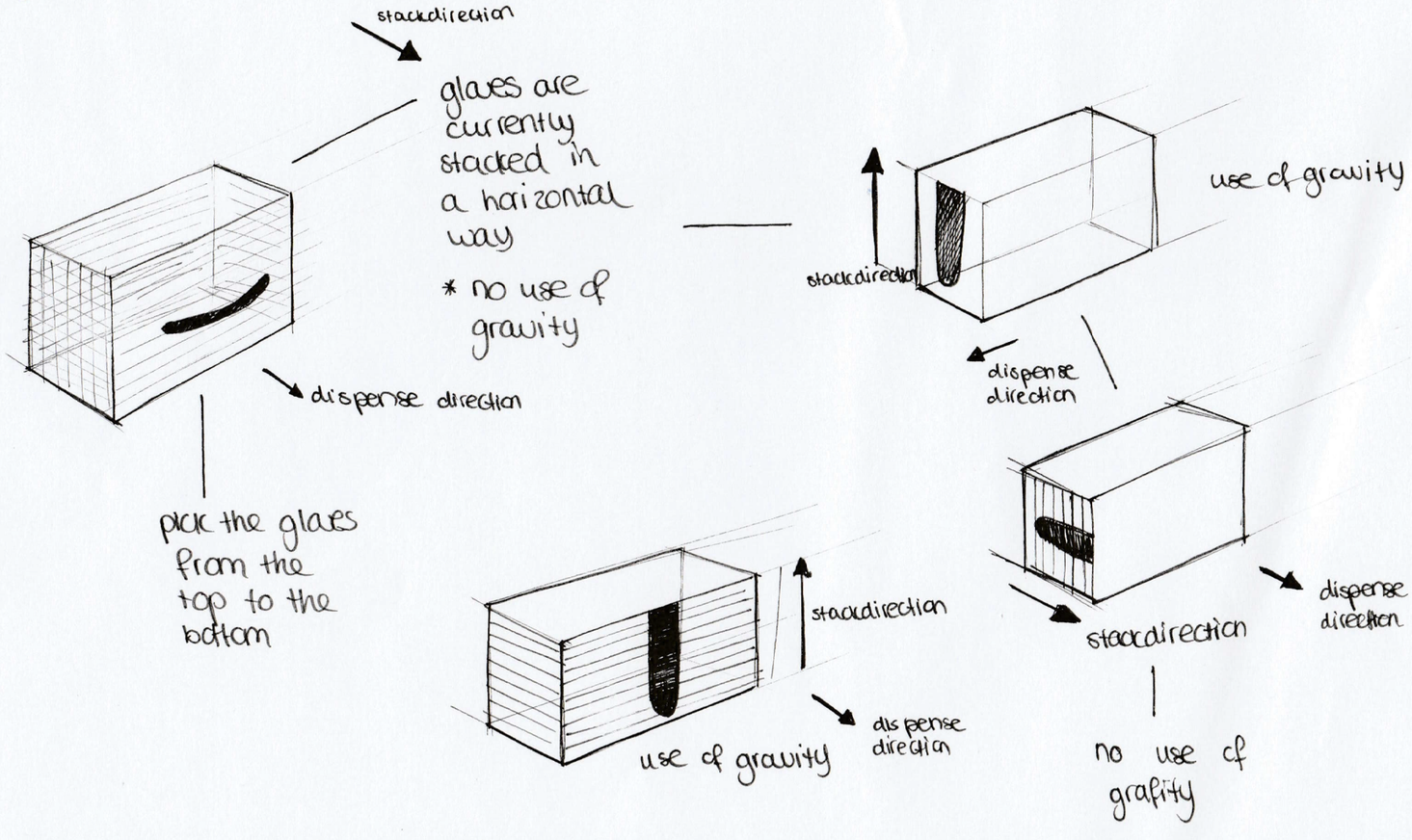
how to clean the temporarily storage?

glave container per size



IDEA 3

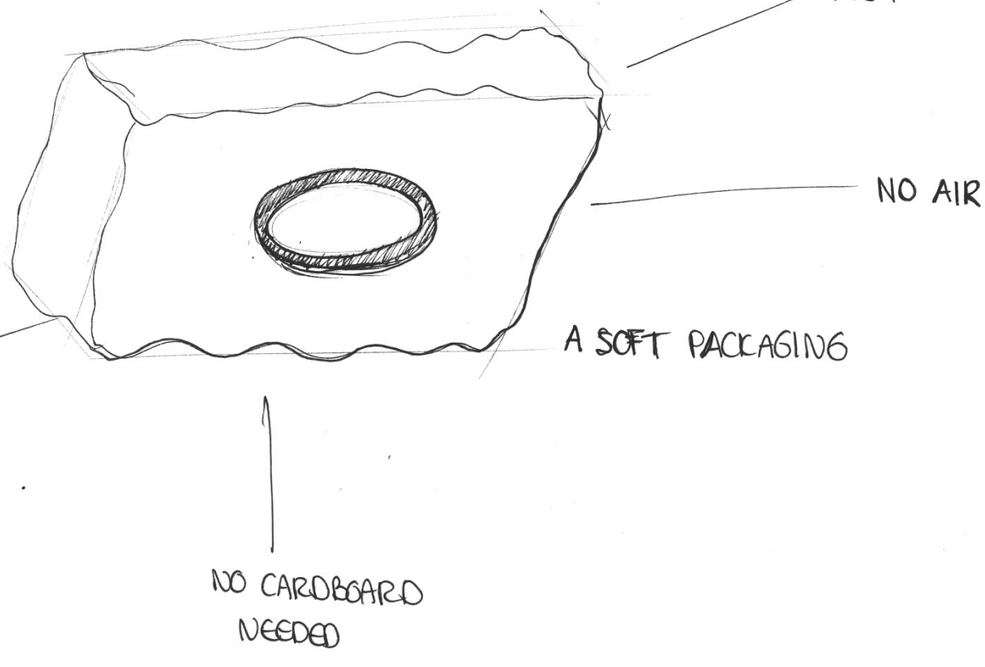
cuff first in the current glave boxes
manually packing



IDEA

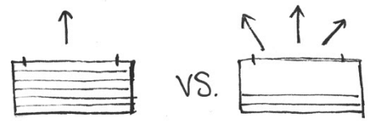
remove the cardboard box

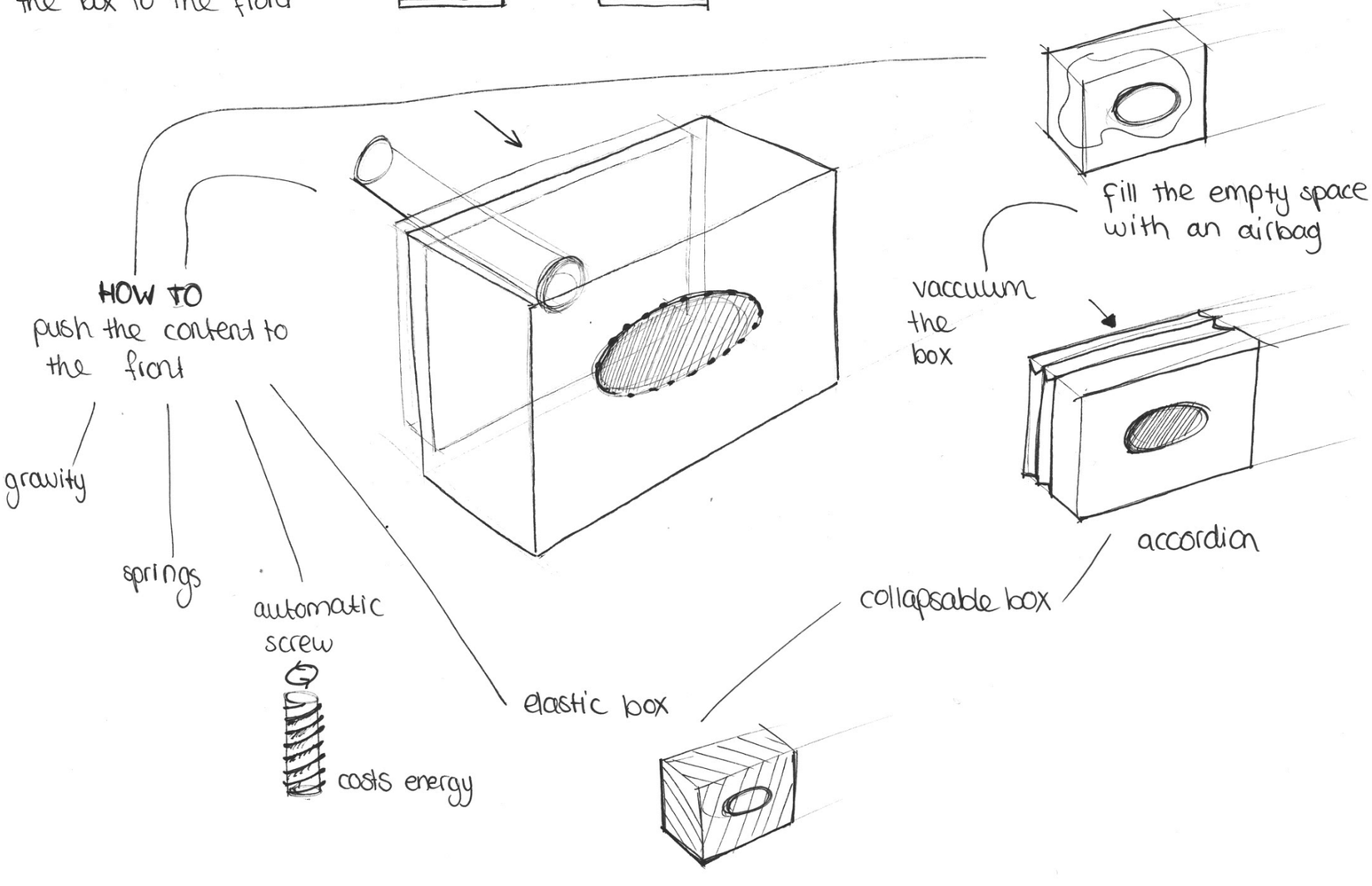
The shape of the box does not match the shape of the glaves



IDEA

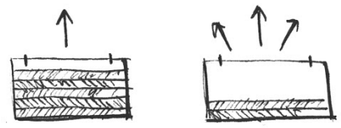
press the content of the box to the front



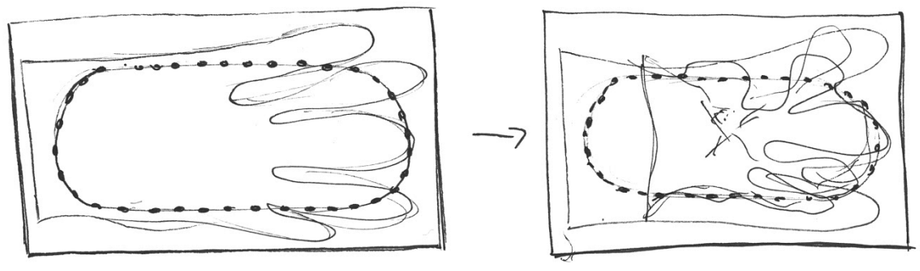


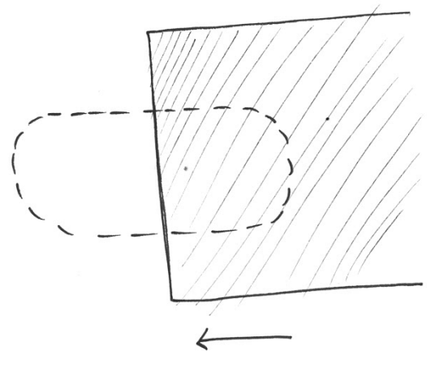
IDEA

change the shape of the opening during use



The Ansell gloves are stacked in a vertical direction — Will not work for gloves that are stacked more random





glove boxes needed to be placed in the right direction "grab at the cuff"

gloves will fall out less easy

cover the opening as the box gets empty

59

GLOVE BOX FRUSTRATIONS

ADD to the analysation
- bottom; gloves are able to move side wards

make side ward moving unable

box is too full

not clear where to grap the first glove

opening does not open easily

cardboard tears open around the line

opening makes it easy to put the gloves back

how long do micro-organisms survive?

pieces of cardboard on the gloves

Aim-X is the plastic layer supposed to be in front of the openin

difficult to reach the bottom gloves

able to move side wards

take the hole to unch of gloves out

no clear starting point to open the box

gloves stick together

fold the glove box — different shape

or

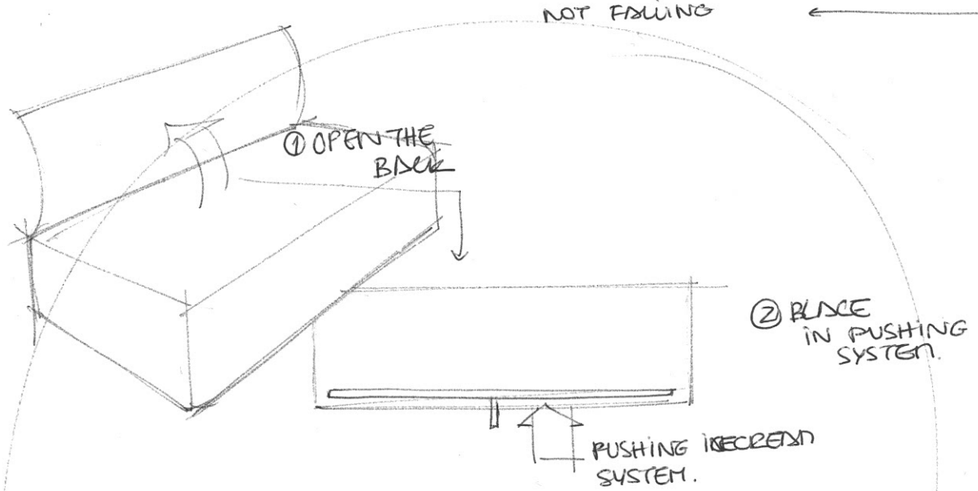
HOW TO design a one size fits all add on

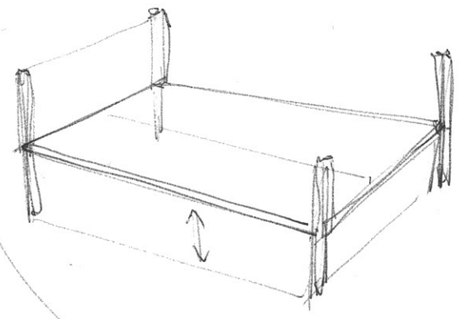
or design for the main brand

OPENING, PACKAGING, PACKING
differs per brand,
what are there reasons behind those designs

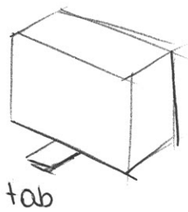
60

NOT FALLING ← REDUCE UNUSED → REUSE FALLING.



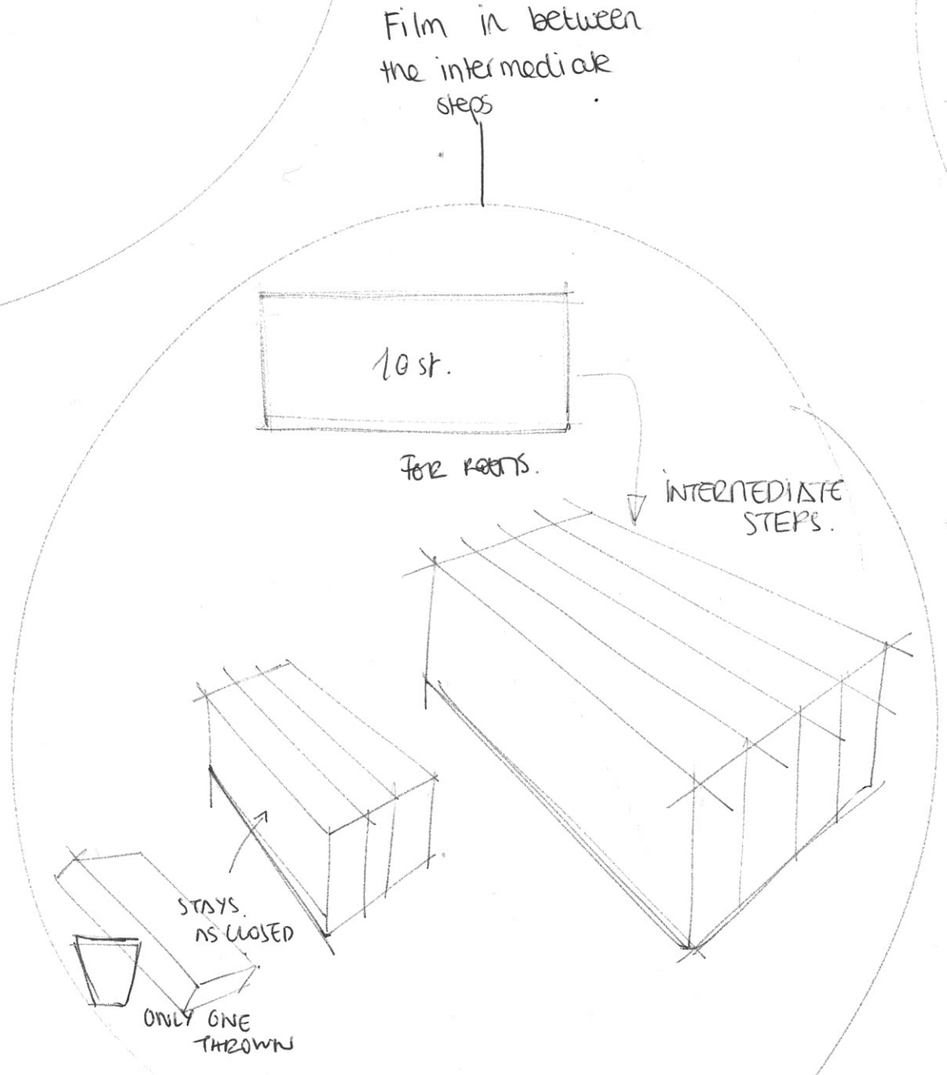


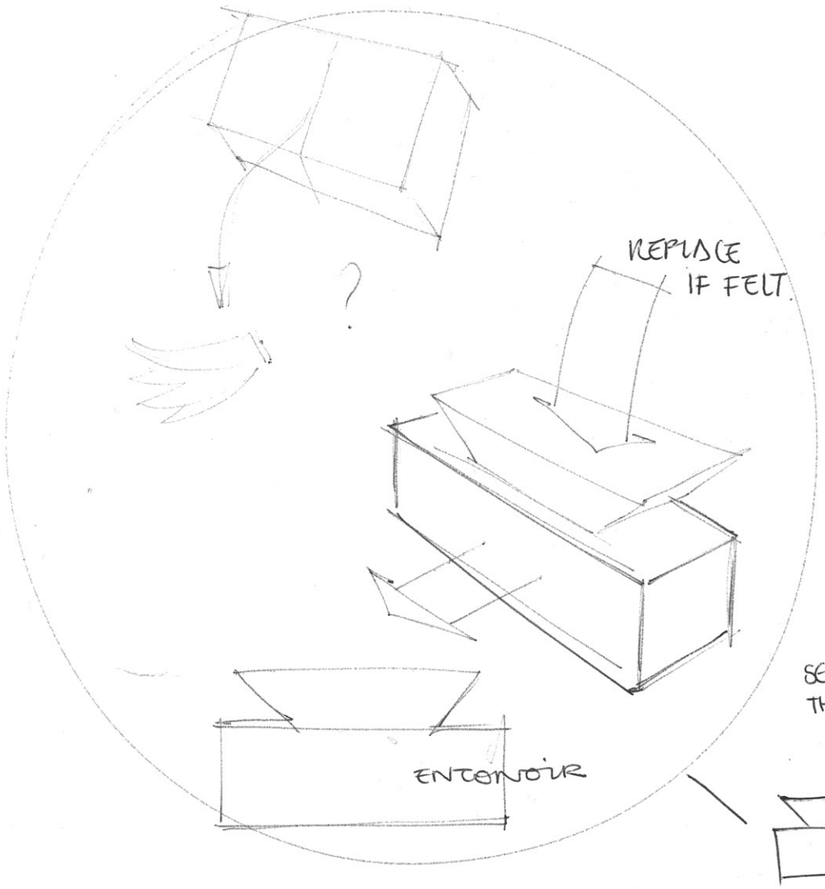
HOW TO PUSH THE SYSTEM

- ELECTRICAL
  - every time the door opens the system will push the glaves
- SPRINGS
  - 

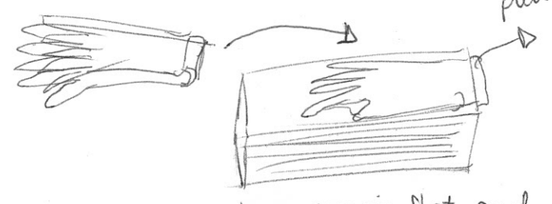
- SCREWS

Film in between the intermediate steps





Fold gloves per pair, so a pair comes out together



gloves remain flat and in order when picked from the top

reduce unused gloves

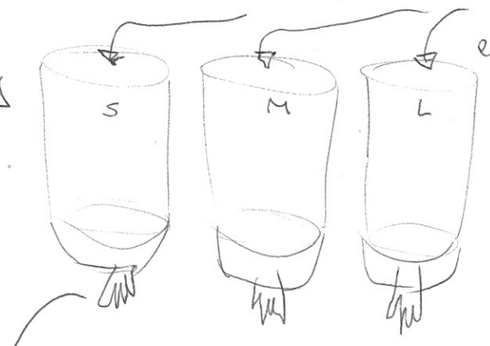
XL L M S

CREATE DATA!
project that does collect data on how many are used, and from there procurement improvement can be done

ERGONOMICS DATA TO CALCULATE THE NUMBER OF GLOVES PER SIZE

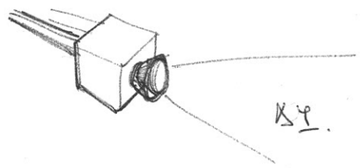
CALCULATE THE NUMBER OF GLOVES NEEDED FOR A CERTAIN PATIEN

silo's as a new dispensing system

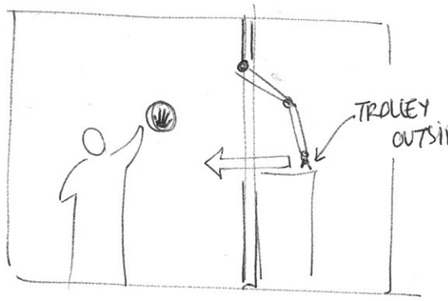


open and empty boxes in here

pick ~~up~~ gloves underneath



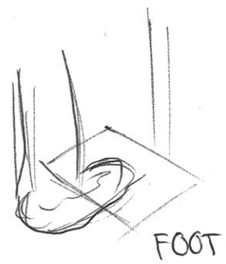
KEY.



automated process, gloves stored outside of the room.

automated dispenser where only two gloves come ~~out~~ at a time

USE HUMAN POWER



FOOT

ORANGE JUICE MACHINE

side view

gloves roll out of the dispenser to ensure that no too many comes out at once and that the gloves do not fall out on the floor

REDUCE THE NUMBER OF UN-USED GLOVES

very big opening = easy to pick right amount of gloves

NEW ONE-BY-ONE FOLDING PATTERN

ORIGAMI

STORE THEM FOR LATER

PACKAGE PER PIECE

ONE BY ONE

1 BY 1 ?

AUTOMATED TAKE OUT

NO TOUCHING!

PUSH THE GLOVES TO THE FRONT

USE GRAVITY

box with glove-shaped hole at the top + vertically stacked gloves

MULTIPLE HOLES ?

VERTICAL DISPENSION

FLEXIBLE BOX

COLLAPSIBLE BOX

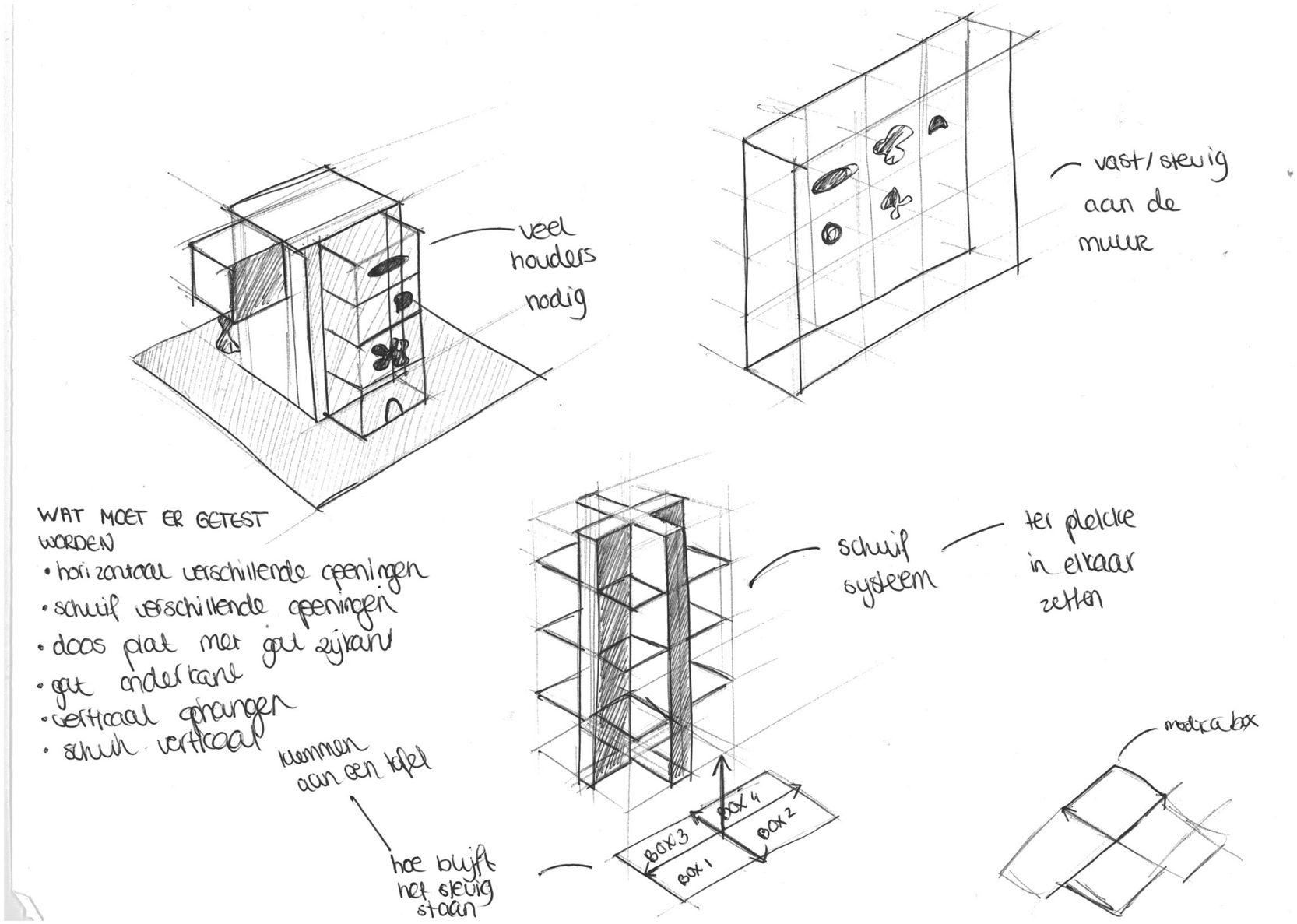
ORIGAMI

HOLE CAN CHANGE SIZES ?

PUSHING THE GLOVES OUT

Appendix E: Product Usability Evaluation

Appendix E.1: Mobile test station



Appendix E.2: Evaluation approach

In the design phase of the project, prototypes were created. The prototypes contain addition to the existing opening (silicon plates), a different shape of the existing opening or have a different direction of dispensing. The prototypes were tested by trying to pick the gloves one by one. Three prototypes that could decrease the number of gloves were selected from these prototype tests.

The prototypes are still intermediate designs and do not fulfil all requirements. The three-dimensional models are not evaluated by the user. However, the knowledge and experience of the end-user can provide valuable insights. Therefore, the prototypes are tested with the users based on the Product Usability Evaluation.

The aim

The research aims to discover how the prototypes are experienced by the user to find useful issues, such as errors and misunderstandings and possible improvements.

Method

The used method is the Product Usability Evaluation as described in the Delft Design Guide. Product Usability Evaluation serves to validate product usability, enabling you to understand the quality of your designs (ideas or concepts) in actual use conditions. You can modify your design based on the outcomes.
Product Usability Evaluations are typically conducted at several points of the design process. In each stage of the process, different things can be evaluated. In the case of this project, the method is used to evaluate the use of intermediate design using three-dimensional prototypes.

The evaluations' outcomes can help generate requirements for efficiency, effectiveness, and satisfaction. Additionally, useful issues, such as errors and misunderstandings, possible improvements to resolve those issues and opportunities to improve the user experience of the design can be discovered.

Procedure

The first step is to invite the participants to do the evaluation test. In this case, the evaluation was done in the healthcare context and it was planned on two afternoons during the clinical lesson time.
Initially, an Evaluation Form was designed to evaluate the design in more detail, see Appendix [fixme]. However, the staff did have less time than expected, so the evaluation was changed to a shorter one.
The participants were asked to try out every glove box two times. The participants were asked to think out loud while performing the test. After trying out all glove boxes the participants should give their preference on a box. Afterwards, the test and the preferences were discussed during a conversation, depending on the time available.

1. Welcome the participants and explain the user test
2. Invite the participants to try
3. Observe the participants and take notes
4. Discuss the results
5. Thank the participants

Information processing

The information was processed by reading through all the notes of the observation. Overarching themes were looked for. The opinions are divided into different clusters.

Appendix E.3: User evaluation form

Handschoenen test evaluatieformulier

Project: Reducing the environmental impact of gloves used in the ICU – TU Delft

Doel van het onderzoek: Het doel van dit onderzoek is om nieuwe handschoenen dozen te testen.

Uitleg van het onderzoek
In figuur 1 is het handschoenen test station te zien. In de houder zijn verschillende handschoenen dozen geplaatst. De handschoenen dozen hebben verschillende posities en openingen. De handschoenen dozen zijn genummerd.
U wordt gevraagd om per doos twee keer een handschoen uit de doos te pakken. De pijl geeft aan in welke richting de handschoen uit de doos gehaald moet worden. Het kan zijn dat de handschoen niet helemaal goed uit de doos komt of dat er meerdere handschoenen uit komen.
Wanneer u twee keer handschoenen heeft gepakt, kunt u ze weggooien in het ronde gat. Vervolgens kunt u op het evaluatie formulier uw mening uiten over de handschoenen doos. Er zijn geen goede of foute antwoorden, het gaat om uw mening.

Figure 1: Mobiel test station

Het onderzoek is anoniem, maar ik heb wel een aantal gegevens van u nodig:

Ik draag normaal handschoenen in maat: **o S** **o M** **o L** **o XL**

Ik geef toestemming om mijn antwoorden te gebruiken voor het afstudeer onderzoek van Lisanne van den Berg voor de studie Industrieel Ontwerpen: **o Ja** **o Nee**

Doos 1

Poging 1: er komen ..... handschoenen uit de doos

Poging 2: er komen ..... handschoenen uit de doos

Het pakken van de handschoen is makkelijk

o helemaal mee eens o mee eens o neutraal o oneens o helemaal mee oneens

De positie (horizontaal, verticaal, liggend) van de doos is handig

o helemaal mee eens o mee eens o neutraal o oneens o helemaal mee oneens

De beweging die ik moet maken om de handschoen te pakken vind ik fijn

o helemaal mee eens o mee eens o neutraal o oneens o helemaal mee oneens

Wat vind u goed of slecht aan deze verpakking:

.....
.....
.....
.....
.....
.....

[Herhaal voor elke verpakking]

Welke handschoenen doos heeft uw voorkeur en waarom?

.....
.....
.....

Welke handschoenen doos heeft NIET uw voorkeur en waarom?

.....
.....
.....

Bedankt voor het uitvoeren van de handschoenen test.
Heeft u nog vragen, opmerkingen, suggesties?

.....
.....
.....
.....
.....
.....
.....