

# Design guide for better usable operable façade elements (OFE's) for offices in the Netherlands

P5

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# Problem statement

In practice, OFE's in offices are often not appropriate to use for control over thermal environment and indoor air quality.



While office workers still:  
Often suffer from building related symptoms  
  
Are regularly dissatisfied with the air quality and thermal environment  
  
Whereby one of the reasons is 'lack of options for personal control'



# Content

	Aim
I.Research	Literature survey BBA Database analysis Context mapping study
II.End Products	Requirements OFE Design Factsheet Design Guide
	Discussion & Reflection
	Conclusion
	Planning

# Aim

Develop a **design guide** for designers of Dutch office buildings and façades in such a way that it **helps to design** operable façade elements which are **better usable** and thereby improve **personal control** over **thermal environment** and **indoor air quality**.



# Research questions 1&2

- Which aspects affect the usability of operable façade elements for personal control on thermal comfort and air quality?
- Which requirements help to design better usable operable façade elements which enhance personal control over thermal environment and air quality?

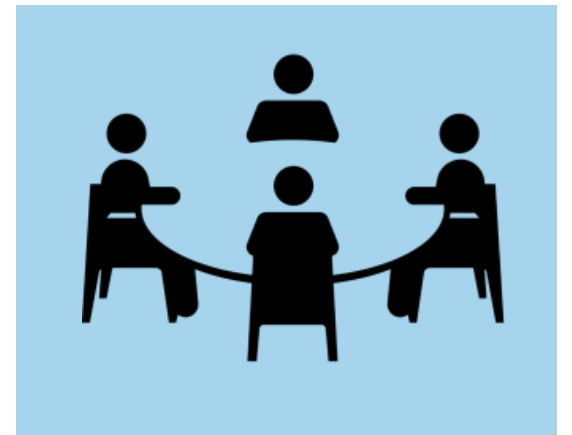
## Literature survey



## BBA Database analysis



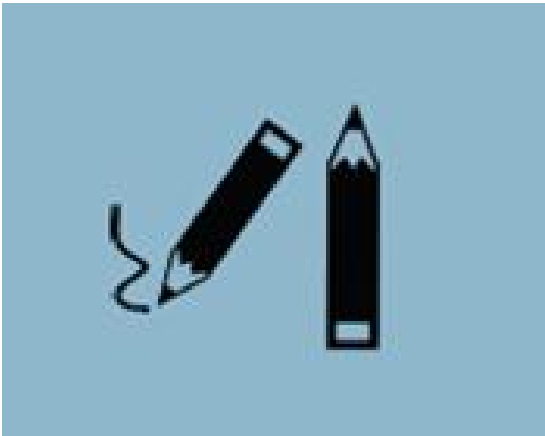
## Context mapping



# Research questions 3&4

- How can an operable façade element that properly integrates these requirements look like?
- How can designers use this information for façade design with better usable operable façade elements?

## OFE Design



## Design Guide



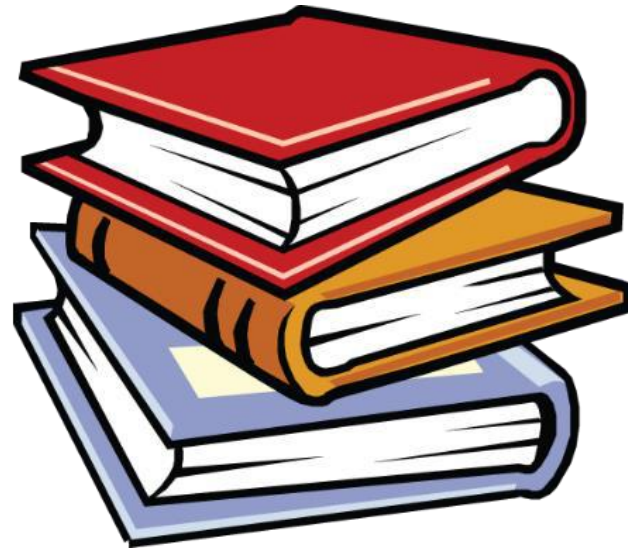


# Literature survey - Method

**Books**

**Search engines**

**Journals**



**Keywords:**

*Operable window  
(Natural) ventilation*

*Adjustable  
Usability*

*Health  
Comfort*

*Satisfaction  
Productivity*



# Literature survey - Themes

Effects of OFE's



Aspects of OFE's



Usage of OFE's







# Literature survey - Results

Which aspects affect the usability of operable façade elements for personal control on thermal comfort and air quality?

Aspects OFE's have (potential) effect on:
Building performance
Burglary risk
Experience of weather conditions
IAQ (Indoor Air Quality)
Ingress of noise from outside
(Local) Air movement
(Local) Indoor temperature
Motivation to control
Occupant's wellbeing
Personal control
Relation with outside
Responsiveness to users' needs
Robustness
(Sensory) Pleasure
(Thermal) Adaptation
Tolerance/ Forgiveness



Requirements for good usable OFE's
User-friendly
Clear design intent
Effective
Fine-tuning capability/ Adjustable
Match company's security policy and OFE design
Low noise ingress
(Mental) connection with outdoor climate
Proximal/ highly controllable by occupants
Robust
<i>Additional requirement for perceiving control by OFE's over thermal environment &amp; indoor air quality</i>
Cultural/social attitudes match



# BBA Database analysis - Method

## Database:

37 Dutch office buildings with IE complaints (N=2918)  
Conducted by BBA in the past 10 years  
IEQ questionnaires

## Analysis:

OFE related aspects  
Relevant questions  
Photo's  
Open answers

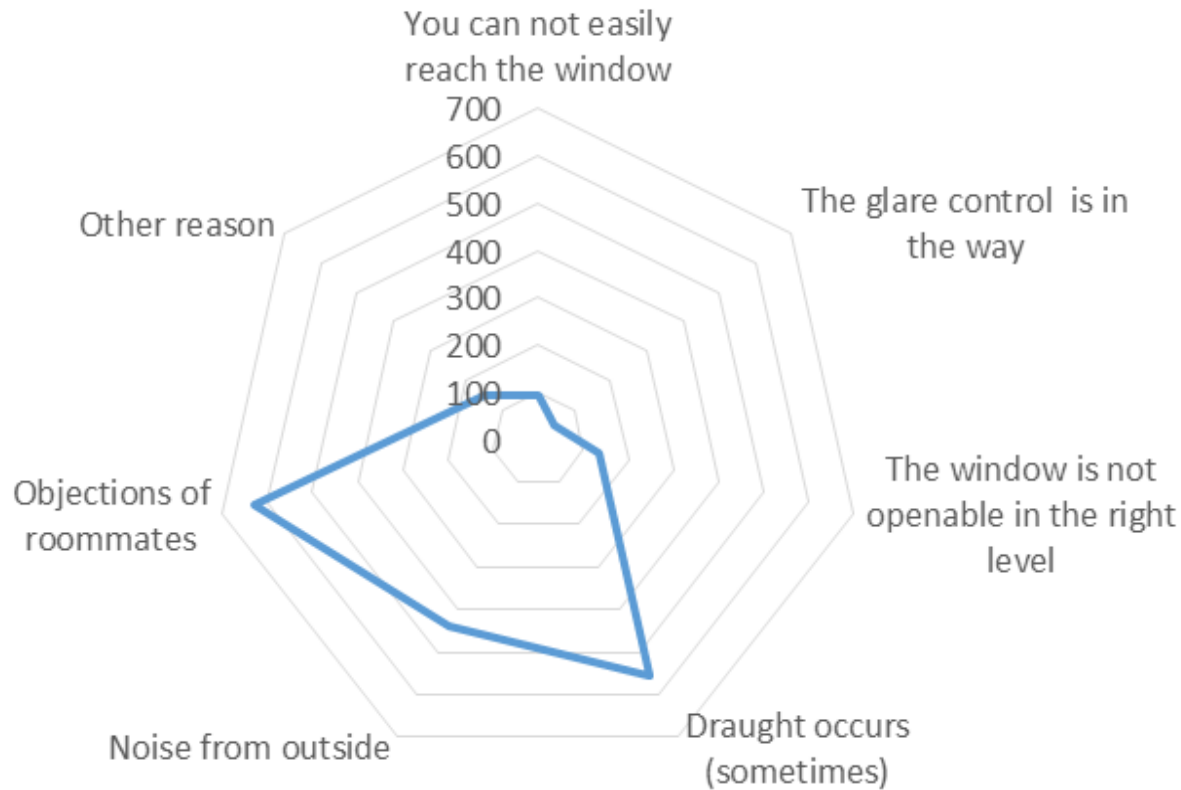




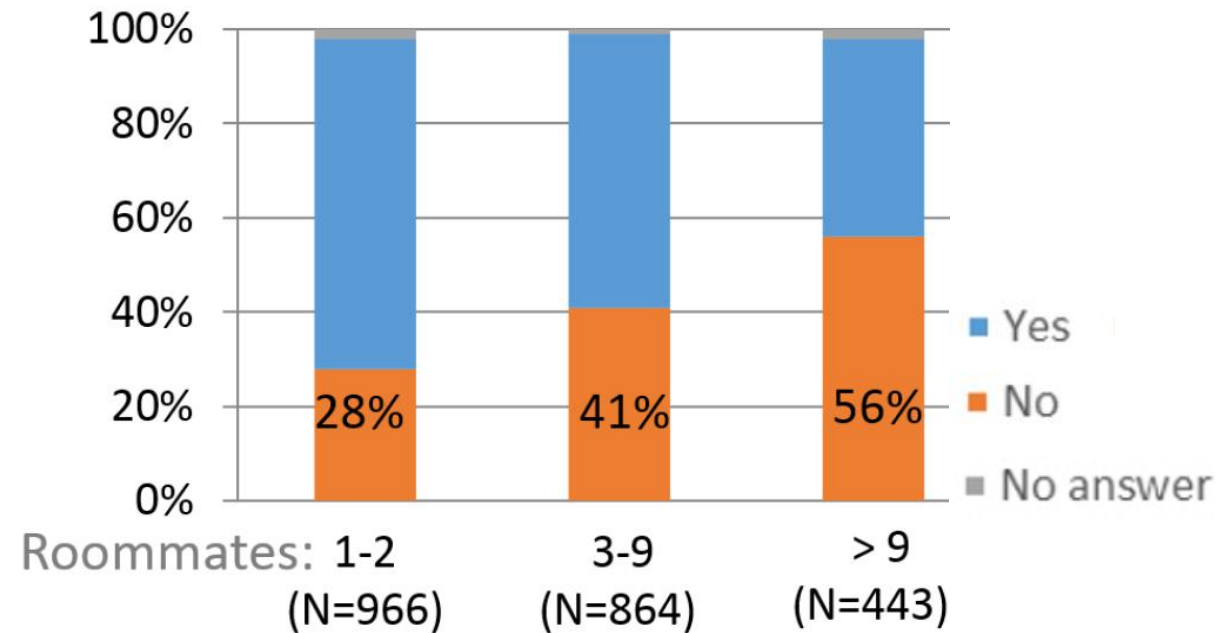
# BBA Database analysis - Results

If you cannot always open the window when needed, what is/are the reason(s) therefore?

(N=2046)

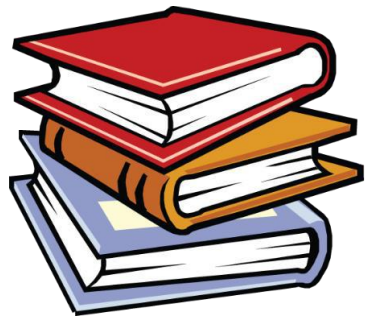
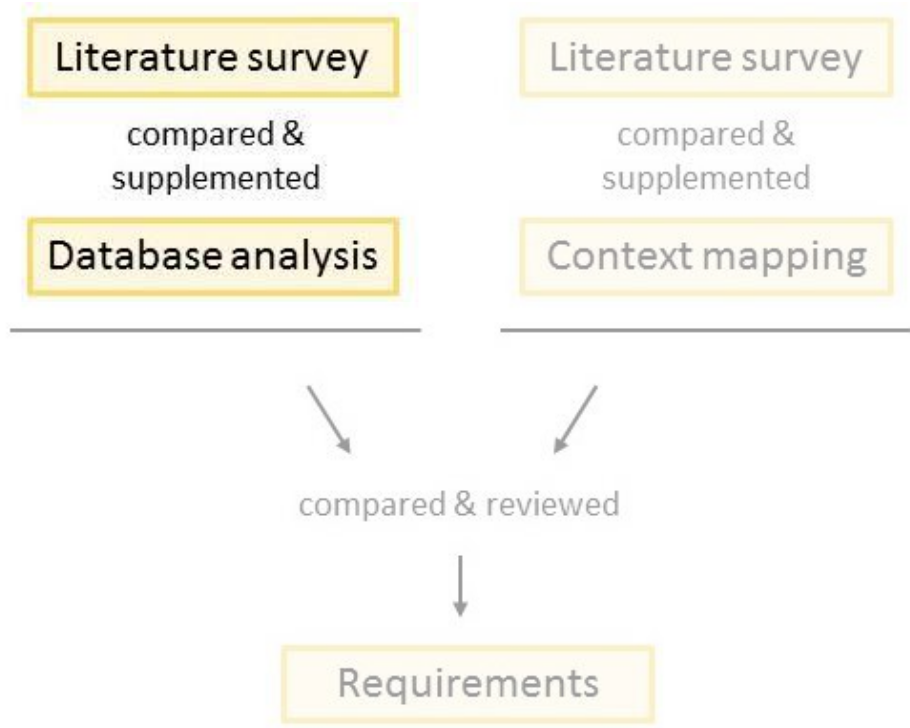


“Can you always open the window when you feel the need to do so?”





# BBA Database analysis - Results



Example:

Requirements for good usable OFE's <b>based on literature</b>	<b>Comments</b> or umbrella terms for comments in the BBA database analysis <b>which indicate that the OFE not appropriately meets the requirement</b>
Robust	Broken, lost or defect (control) element, not easy to open or reach, not clean.



# BBA Database analysis - Results

Requirements for good usable OFE's
User-friendly
Clear design intent
Effective
Fine-tuning capability/ Adjustable
Match company's <b>management &amp;</b> security policy and OFE design
Low noise ingress
(Mental) connection with outdoor climate
Proximal/ highly controllable by occupants
Robust
<i>Additional requirement for perceiving control by OFE's over thermal environment &amp; indoor air quality</i>
Cultural/social attitudes match
Supply is fresh air of sufficient quality

- Confirms
- Confirms
- Confirms
- Confirms

→ **Changed** requirement , added "management &":

*To avoid "opening not allowed"*

- Confirms
- Confirms
- Confirms
- Confirms

→ Confirms

→ **Added** requirement

As response on "Car fumes outside"



# BBA Database analysis - Examples





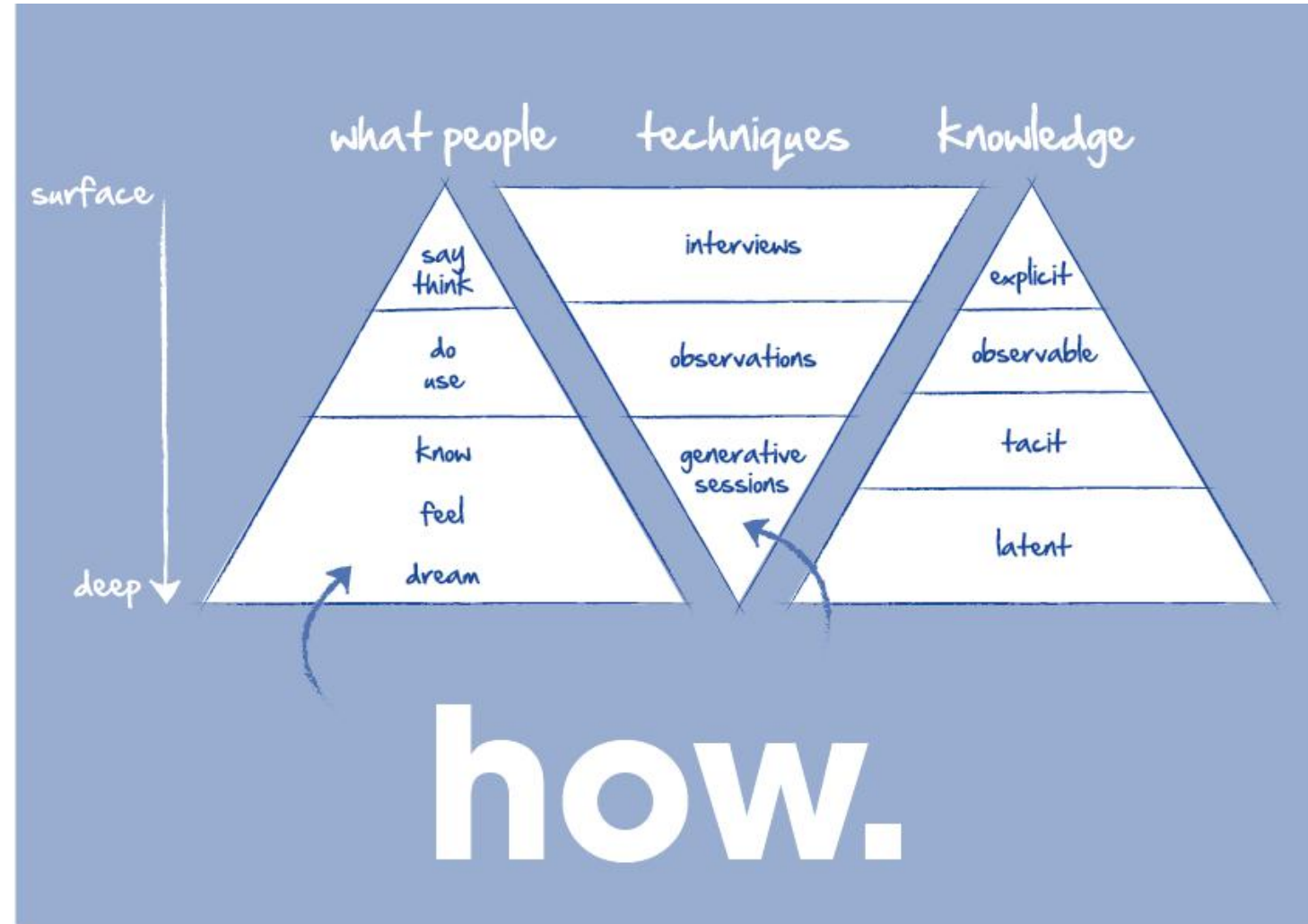
# BBA Database analysis - Examples





# Context mapping – Method

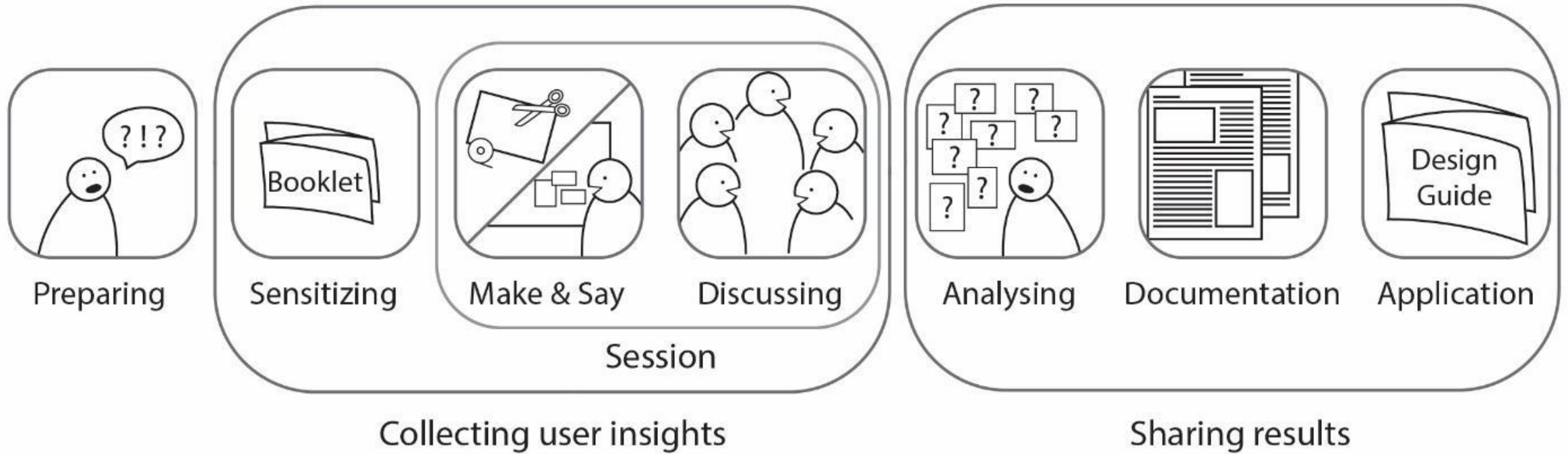
What do people prefer and expect from OFE and why do they do so?







# Context mapping – Method, procedure

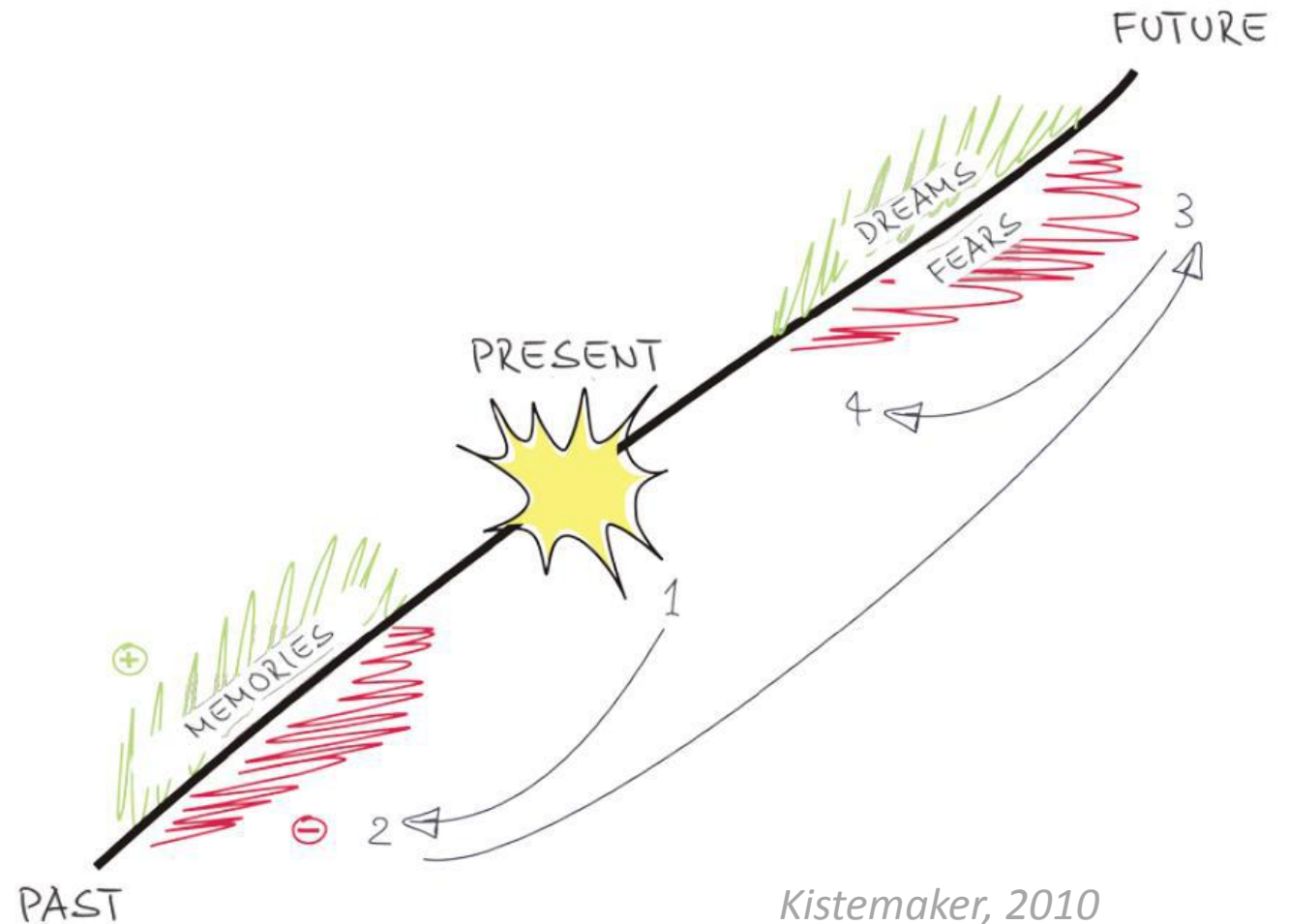




# Context mapping – Method, questions sensitizing booklet

## Sensitizing Booklet

- Factual
- Feel
- Effects
- Ideal



*Kistemaker, 2010*



# Context mapping – Method, location & participants

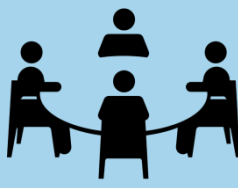
## MultiSense Lab Industrial Design



## Housemates & Neighbours between 18-24 years old







# Context mapping – Method, impression using generative tools

Ranking 6 OFE variant sketches



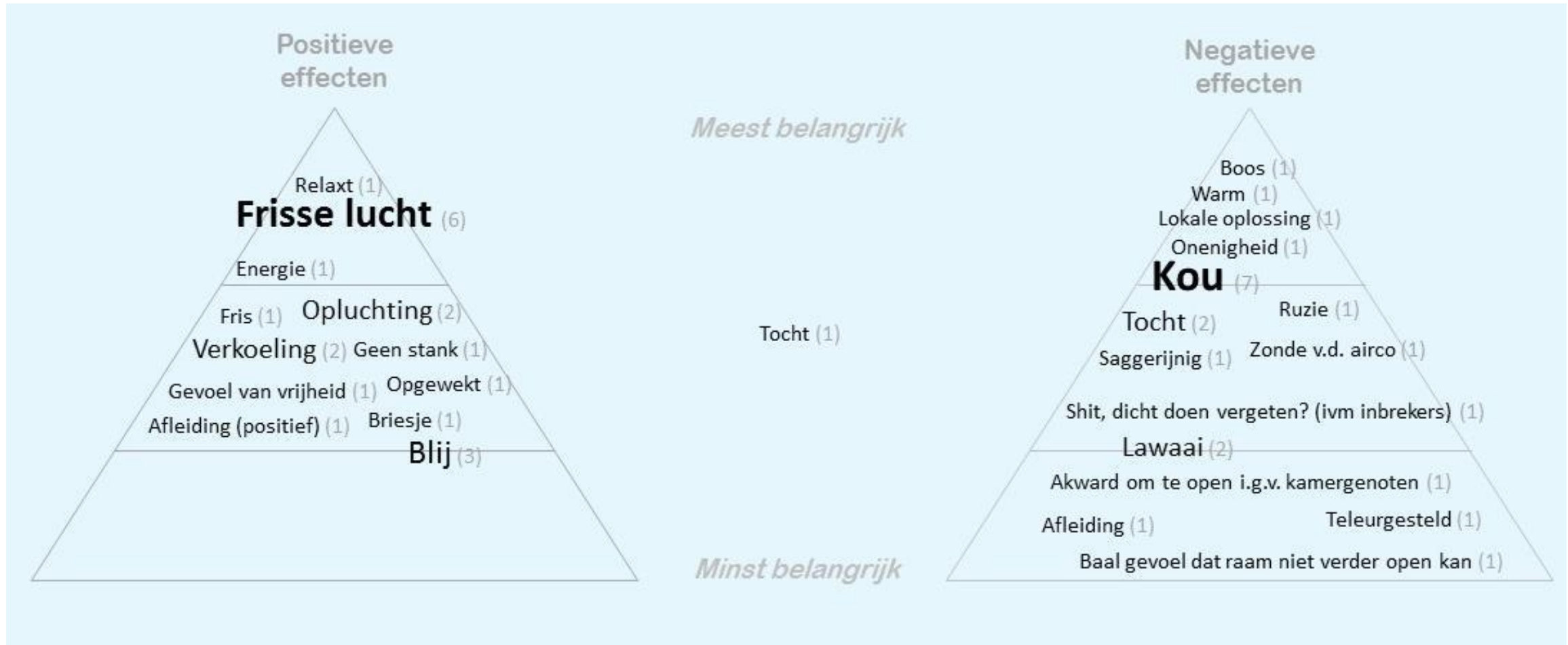
Prioritizing aspects (Card sort)





# Context mapping – Results, sensitizing booklet

Average self-assessed ranking of OFE effects

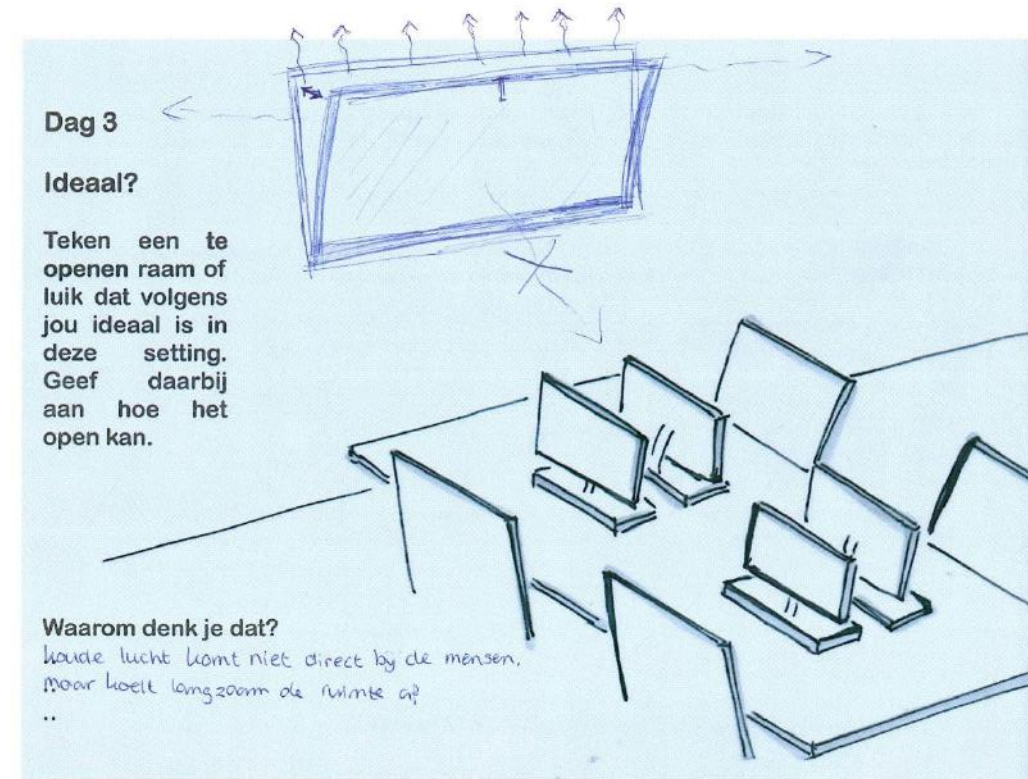
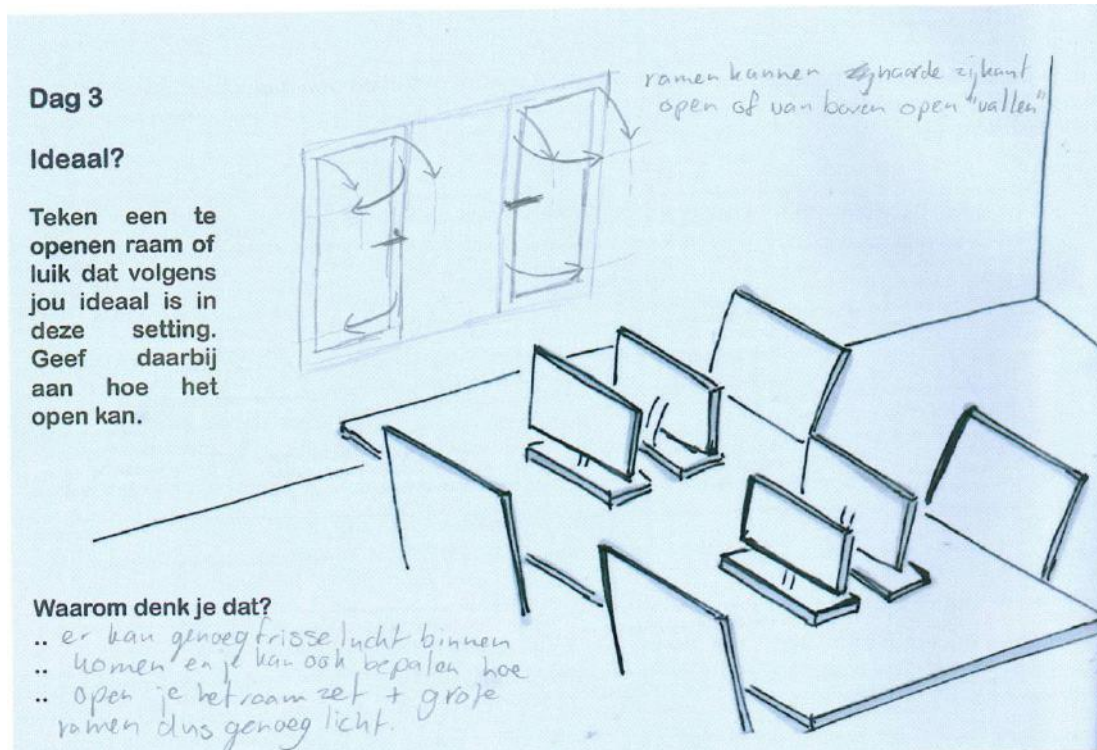






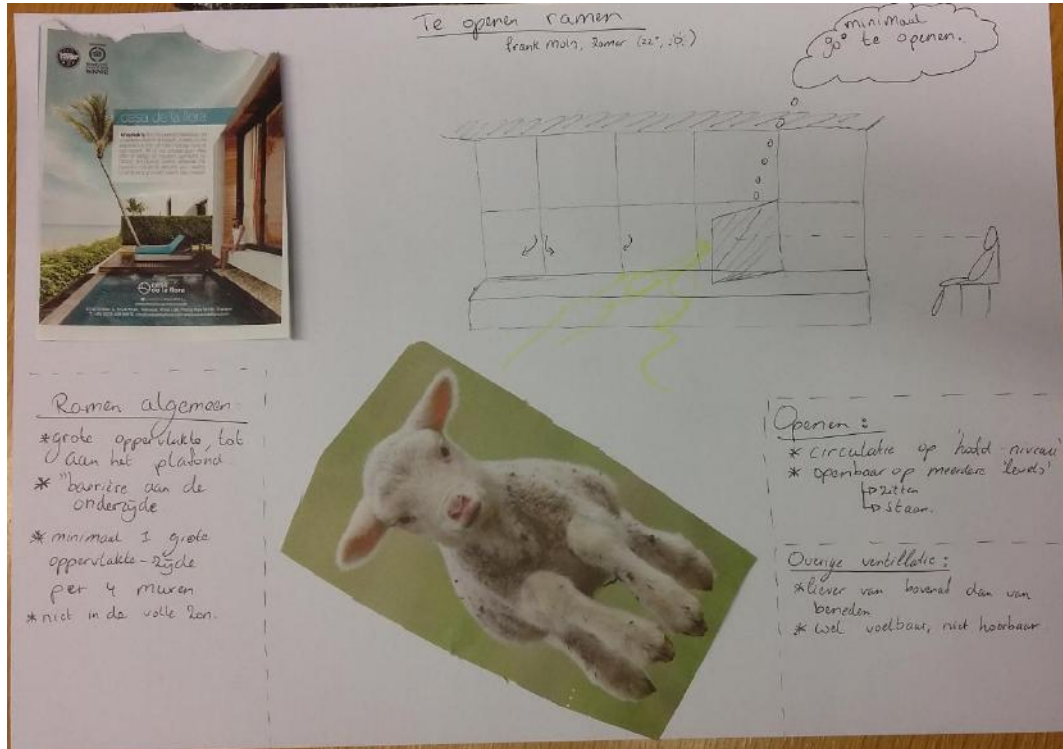
# Context mapping – Results, sensitizing booklet

## Sketches of ideal OFE





# Context mapping – Results, generative tool “collage”



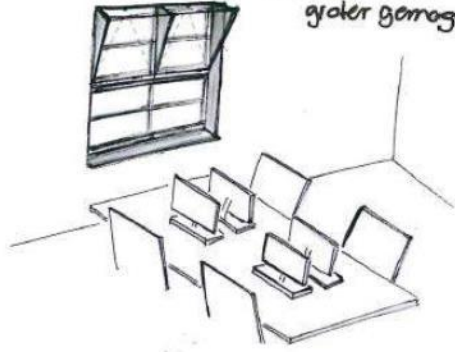




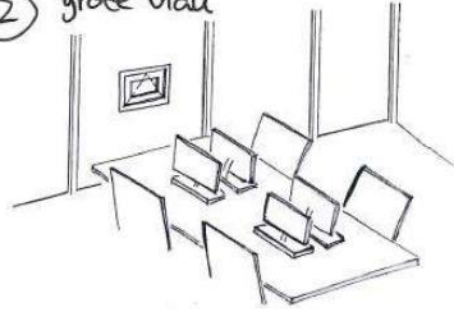
# Context mapping – Result, generative tool “Top 6 of variants”

## Eline

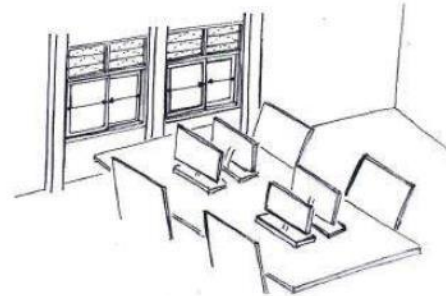
- ① + gedeelte open aan bovenkant + veel glas / veel uitzicht  
+ 1 optie - raam had groter gemogen



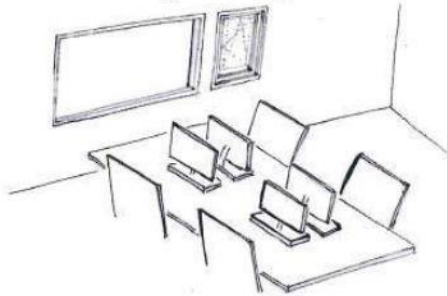
- ② - te openen raampje verpest grote vlak



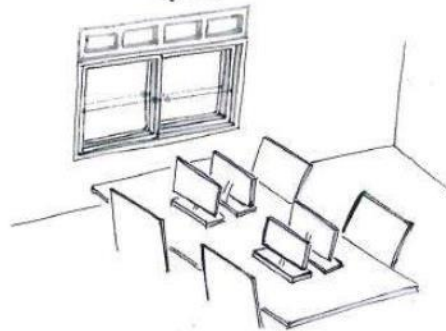
- ③ - te veel opties voor kantoor  
→ veel discussie



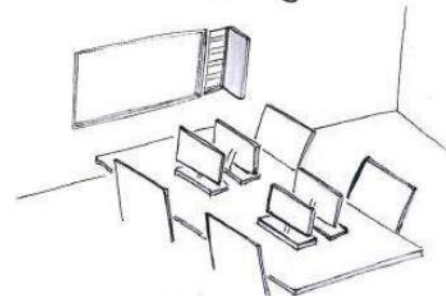
- ④ basic, wel functioneel  
liever 1 geheel glas



- ⑤ - te veel hokjes,  
- liever klein dan groot raam open



- ⑥ - latjes belemmeren  
open gevoel





# Context mapping – Analysis

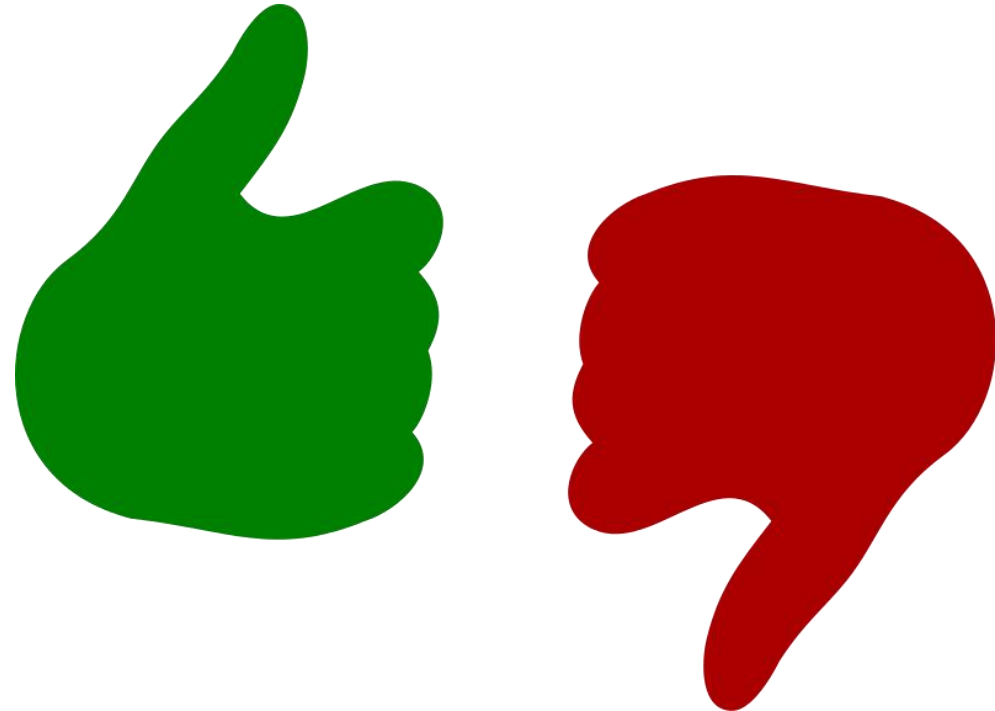
## Outputs:

Sensitizing booklet

- Feel
- Effects
- Ideal

Group session

- Important aspects (collage)
- Pros & cons (OFE variants)
- Priority of OFE related aspects
- Discussion





# Context mapping – results

Mainly expressed by:

OFE's mainly valuable when: warm, stuffy, highly occupied or in case of long stay

*Feel*

Fresh Air  
Cold

*Effects*

Ease of use, low effort & fine-tuning capability

*Ideal & Priority*

View (& light)

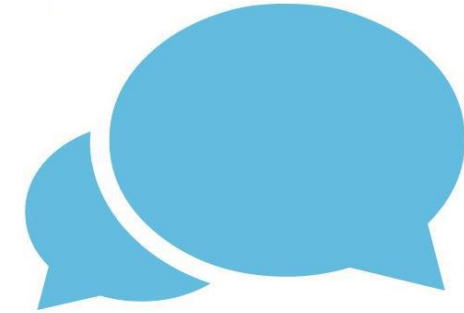
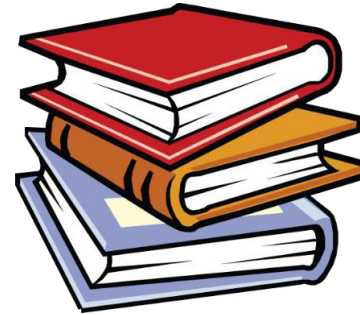
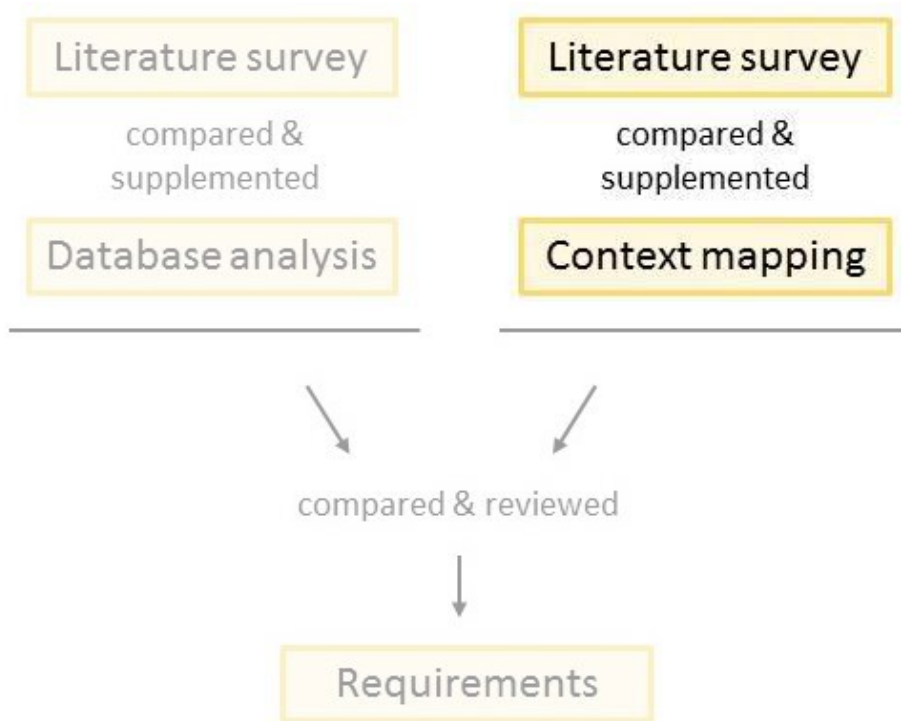
*Top 6*

Usable windowsills

*Discussion*



# Context mapping – results



Example:

Requirements for good usable OFE's based on literature	Related preferences of participants of the context mapping study	Related <b>positive effects/ pros</b> mentioned or illustrated by participants of the context mapping study	Related <b>negative effects/cons</b> mentioned or illustrated by participants of the context mapping study
Robust	Easy to control		Too many options. Difficult to clean



# Context mapping- Results

Requirements for good usable OFE's
User-friendly
Clear design intent
Effective
Fine-tuning capability/ Adjustable
<b>Align</b> company's management & security policy and OFE design
Low noise ingress
(Mental) connection with outdoor climate
Proximal/ highly controllable by occupants
Robust
Supply is fresh air of sufficient quality
<b>Parallel use of windowsill and window</b>
<i>Additional requirement for perceiving control by OFE's over thermal environment &amp; indoor air quality</i>
<i>Cultural/social attitudes match</i>

- Confirms
- Confirms
- Confirms
- Confirms

→ Changed based on database → **Changed into "Align"**

- Confirms
- Confirms
- Confirms
- Confirms

*"Match" was often misinterpreted*

→ Added based on database

→ Added based on database **& context mapping**

*Obstructing stuff in windowsills "Preference for windowsill use"*

→ *Left out based on database & context mapping*

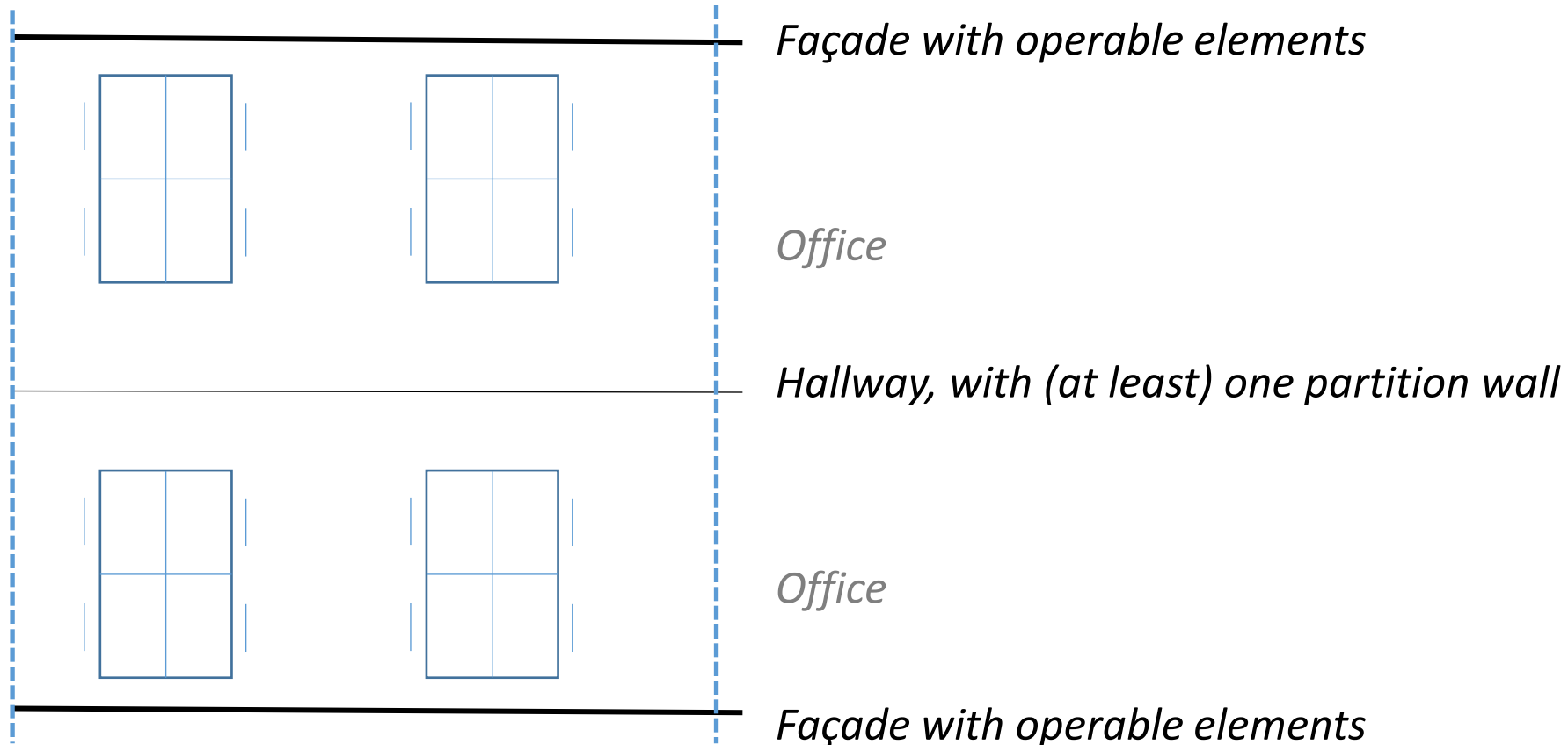
## II. End products - requirements

- User-friendly
- Clear design intent
- Effective
- Supply is fresh air of sufficient quality
- Fine-tuning capability/adjustable
- Low noise ingress
- (Mental) connection with outside
- Proximal/ highly controllable by occupants
- Robust
- Parallel use of windowsill and window
- Align design and management & security policy



# OFE Design - Focus situation

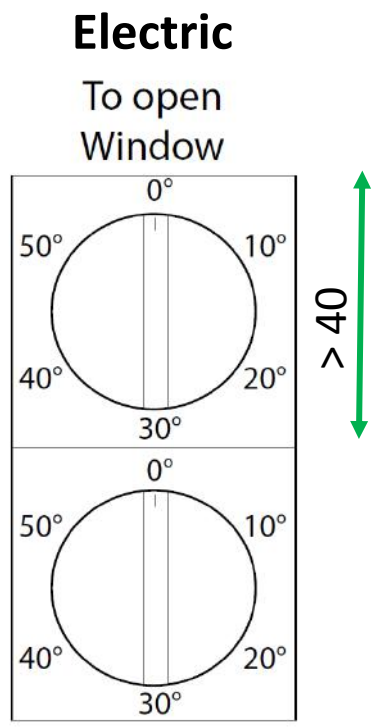
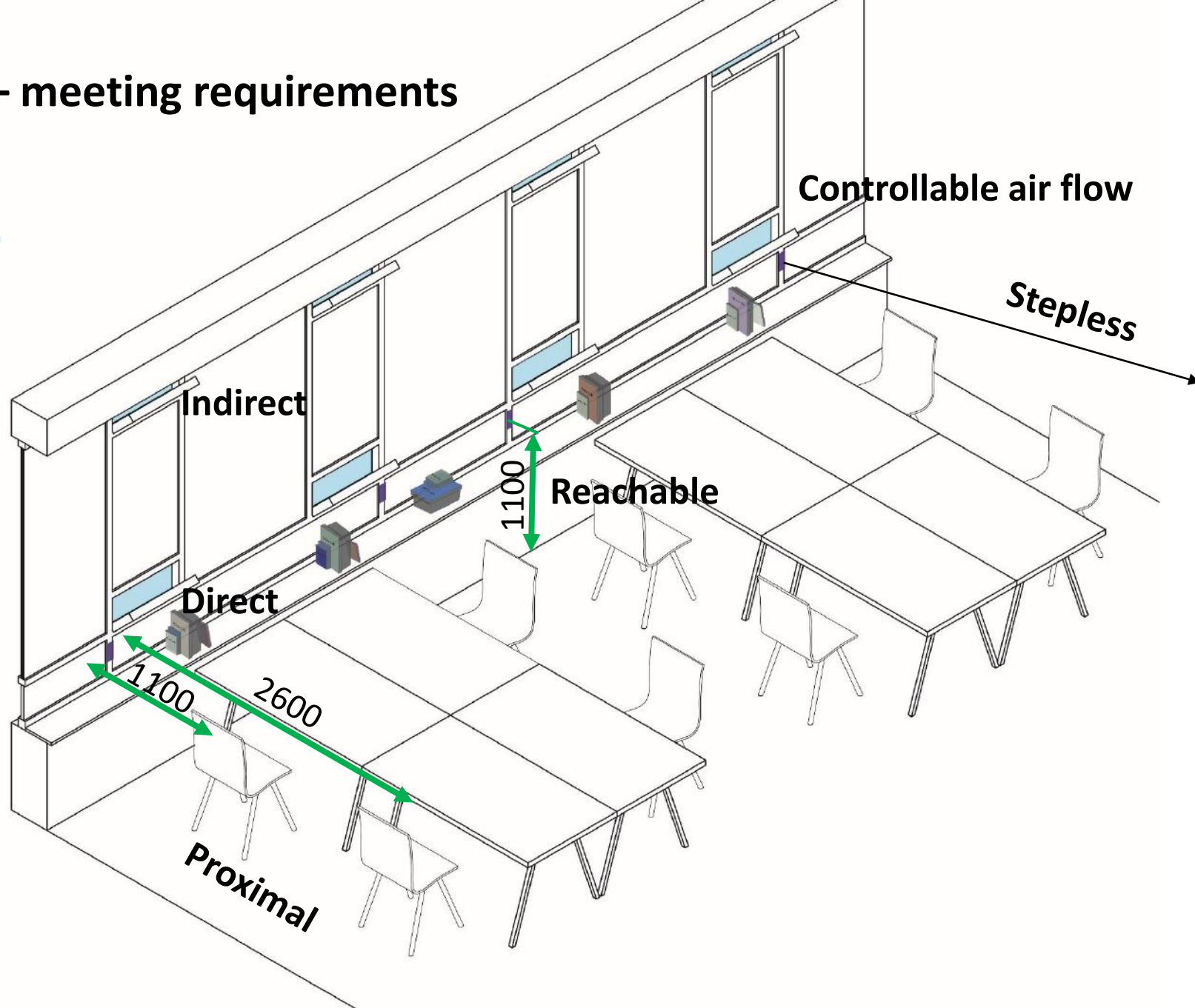
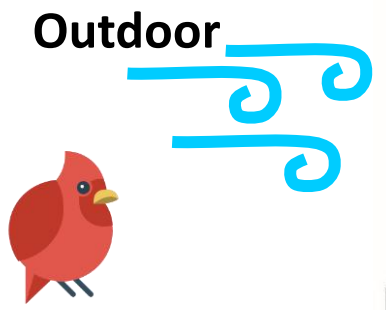
Floorplan, groups of 4 desks along a façade







# OFE Design – meeting requirements

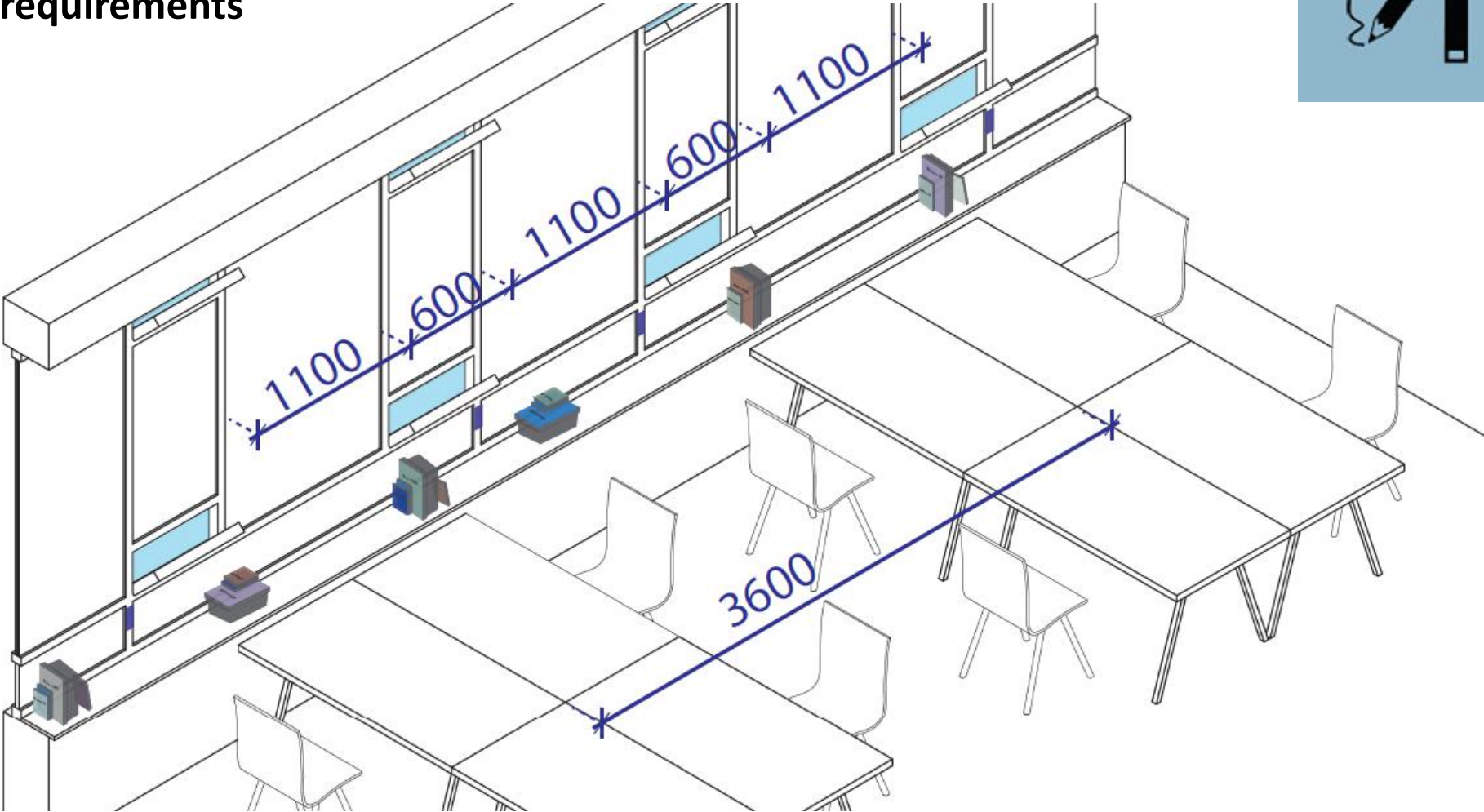
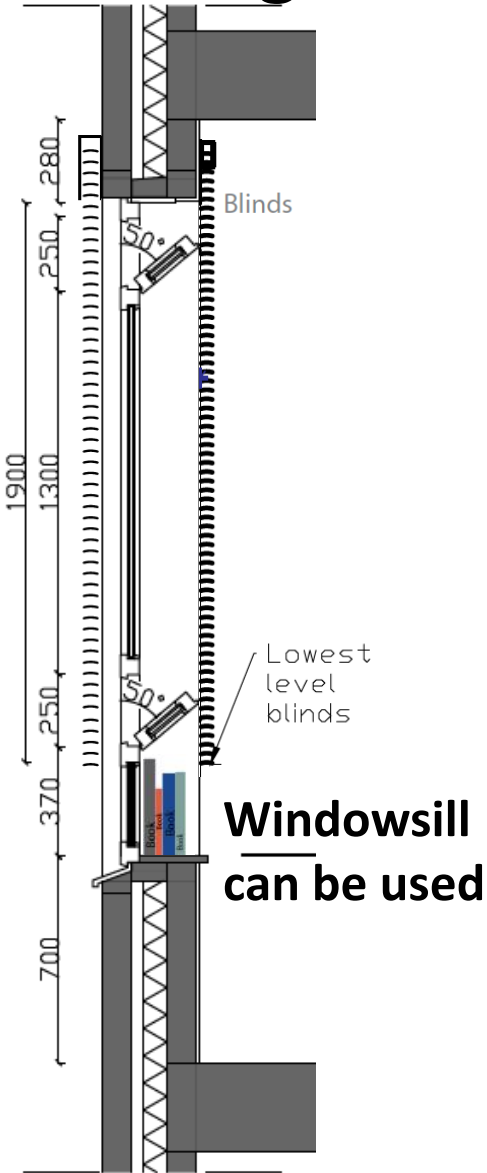


**Robust & Fixed**  
**Easy**





# OFE Design – meeting requirements









# Design Guide

Potential benefit of operable windows

11 requirements for better usable OFE's

- Examples meeting the requirement
- Design suggestions
- Examples

“Designing by sub-choices”






# Design Guide – chapter example

4 pages per requirement


- Examples (practical & BT)
- Design suggestions

1

Examples effective windows



**Project (3.PA)**  
Debis Tower  
Architect  
Renzo Piano  
Location  
Berlin,  
Germany



**Project (3.PB)**  
Art Stable  
Architect  
Jeff Ocampo  
Location  
Seattle,  
Washington,  
United States of  
America

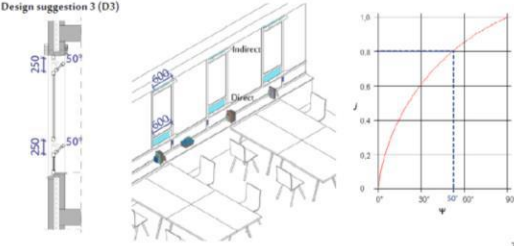
36

### 3. Effective

An effective operable window has an effective opening area sufficient to dilute internally generated pollutants, provide fresh air and to make people feel cooler by air movement. Examples of project with Large effective opening areas are 3.PA and 3.PB.

The size and maximum degree of opening are taken into account for calculating the effective opening area.  $A_{e,eff}(m^2) = A_{net}(m^2) \times f(\alpha)$ . The airflow rate  $q$  ( $dm^3/s$ ) is calculated by the sum of the effective area  $A_{e,eff}(m^2)$  multiplied by the air velocity  $v$  ( $m/s$ ) in the purge component multiplied by 1000 ( $q = A_{e,eff} \times v \times 1000$ ). According to the NEN 1087:2001 the air velocity ( $v$ ) in the purge component becomes 4 times higher in case of cross-ventilation (purge components in non-adjacent façades) than in case of single-sided ventilation, from 0.1 m/s to 0.4 m/s. For example the effective opening area per window of D3 is:  $(0.25 \times 0.6) \times 0.8 = 0.12 m^2$ . As well exhaust ventilation is a driving force, both caused by pressure differences. Note that it can also cause draught or undesired high airflows.

#### Design suggestion 3 (D3)




37

2

3

Example ineffective windows



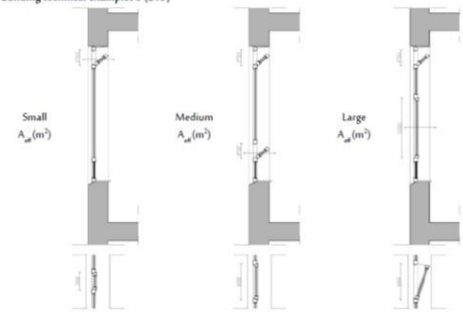
**3E. Ineffective window.** It does not respond to users needs because it opens into an atria.

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### 3. Effective

To achieve effective operable windows some extra attention for 'to avoid situations' can be helpful. To avoid situations: Placement of operable windows along indoor areas such as hallways or atria (3E), small effective opening areas or long distances between occupants and operable parts.

#### Building technical examples 3 (BT3)

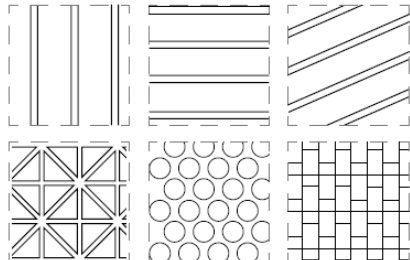
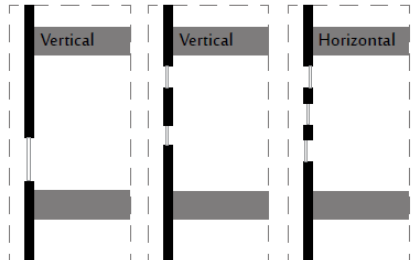
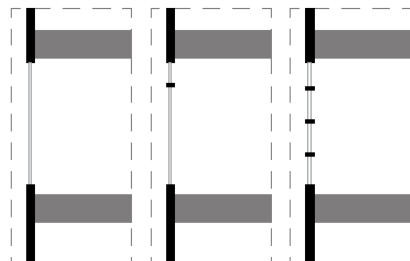
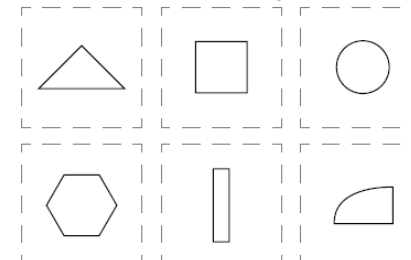
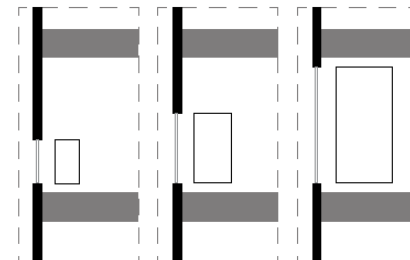
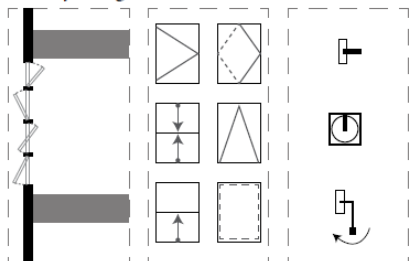
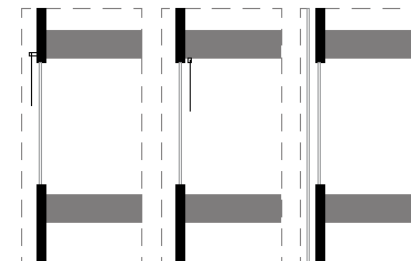
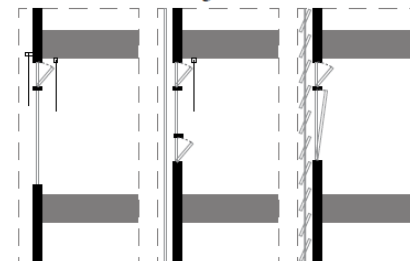


39

4



# Design Guide – Designing by sub-choices

<p><b>1. Pattern and side</b></p>  <p>Which parts will be operable? Can this pattern be aligned with layout in such a way that the one who is most affected has most control over the operable part? (11) How is the noise exposure (6) and outdoor air quality (4)?</p>	<p><b>2. Position</b></p>  <p>! Vertical position determines if it is possible to choose between direct &amp; indirect effect (5&amp;10). Horizontal position determines the width of windowsill. How is the (mental) connection with outside? (7).</p>
<p><b>5. Devision</b></p>  <p>Is it possible to choose between direct &amp; indirect effect? (5). Is it operable while stuff is placed in windowsill? (10)</p>	<p><b>3. Window shape</b></p>  <p>! The shape influences the direction of the air flow. Does the shape guide the air in the right way? If direct effect Is the one where the window is directed to in control? (5) If indirect: Will mixing with indoor air occur? (5)</p> <p><b>4. Size</b></p>  <p>! The size influences the amount of air and air speed. Is it effective enough and controllable? (3&amp;5)</p> <p><b>6. Opening direction, - manner &amp; control</b></p>  <p>! Influences whether it is; robust (incoming rain avoided?) (9), within reach (1), easy to open (2), noise reducing (6) and adjustable (are slamming windows and blowing away of papers avoided?) (5). If inwards opening; check blinds (1), if outwards; check sun shading (1). Has the one most affected most control?(5)</p> <p><b>7. Protectors</b></p>  <p>Which protectors are needed? How can the protectors be integrated in such a way that the operable parts can be opened while the protectors are in use? (5)</p> <p><b>Combining sub-choices</b></p>  <p>! Is it still manageable? (2&amp;9&amp;11)</p>

# Discussion & Reflection

- Comparing and supplementing results
- Suggestions for further research
  - Relation OFE design with:
    - Objections, Acoustical performance and Draught

OFE's in polluted environments  
Relation OFE's & climate control

“Research for better OFE Design”

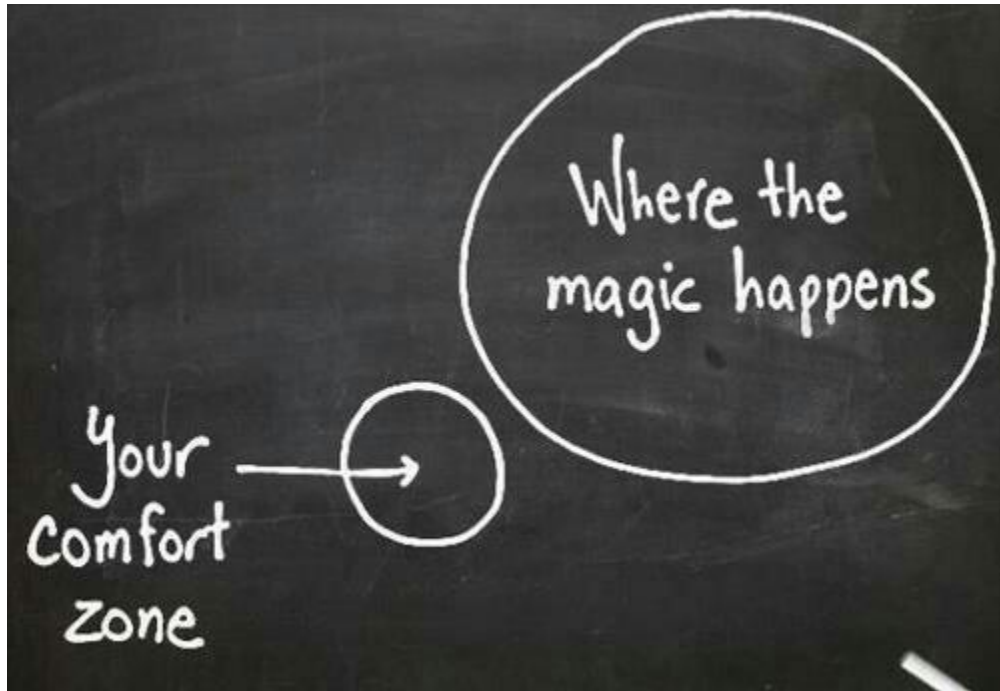
Personal control and indoor air quality improvement → Wider social context





# Discussion & reflection - context mapping

New insights & perspectives



**Next time:**

Multiple group sessions

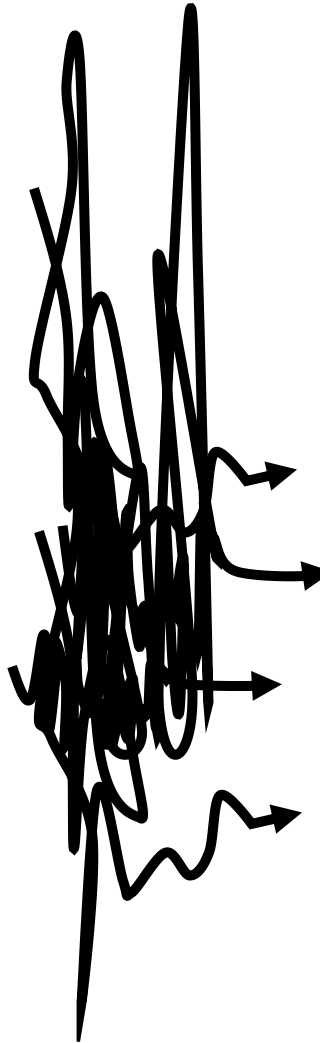
More extensive testing up front

Ask an assistant



# Conclusion

- Which aspects affect the usability of operable façade elements for personal control on thermal comfort and air quality?
- How do these aspects affect the usability of operable façade elements?
- How can an operable façade element that meets these criteria look like?
- How can designers use this information for façade design with better usable operable façade elements?





# End

