Master graduation project

Design for a Better Hygiene Experience in a Flying-V Aircraft

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Ch1.
Background research

Research question

Aircrafts have been used for long-distance transportation since the early 1900s. Many redesigns have improved in-flight comfort levels over the decades (Vink & Brauer, 2011), especially for long-haul flights (i.e., flights with a duration of 6-17 hours). However, much work remains to be done. While Ahmadpour et al. (2014) and Bouwens et al. (2018) have shown the need to improve the seating, attention is also needed in areas including noise, smell, climate and space. The literature outlines some of the current issues, which may be of help in defining future needs. For instance, the limited possibilities to change position and feelings of boredom were issues mentioned by Kremser et al. (2012). As early as 1975, the same authors described how people were concerned with the sense of physically restricted space. In 1999, 930 passengers evaluated different styles of seats, considering various factors including legroom, back support and head support, each of which were rated either poor or very poor by the highest percentage of surveyed passengers(Kremser et al, 2012). A study by Li et al. (2017) confirms these findings. Bouwens et al. (2017) have also shown that boredom is an issue for passengers on long-haul flights. Sleeping and the sense of being bored produce the lowest comfort scores, especially in cruise flight.

In terms of future aircraft design, it hence seems there is scope for improvement. Specifically, in terms of future design, the question arises as to what elements allow for a comfortable journey. We envision that automation will be introduced to flying within the next 30 years. AR and VR technology will be widely used in airplanes, and the cabin crew will be a combination of people and robots. Self-service for some simple tasks such as getting drinks and on-b opping will be permitted.

Perhaps introduce this: At TU-Delft w aircraft is in development: ying V. Th n opportunity to design new rior eleme o increase comfort and is th text of th Sc

thesis.

The airplane, which is shaped in a flying wing configuration, holds up to 315 passengers, which is comparable to a typical wide-body aircraft like the A350. The body of the Flying V is relatively flat. This includes some space that could not be used for carrying passengers due to its low height. The research question chosen for this master thesis is: What elements can be designed to improve the passenger experience within the context of the flying V (a long-haul aircraft of tomorrow)?

04

Methods

To answer the research question first three co-creation sessions were set up to consider the elements that could potentially improve passenger experience during long-haul flights. The aim was to get an overview of the negative aspects of the current flying experience and to establish a direction for future improvements. A survey was then designed and carried out based on data from these sessions. Sanders et al. (2012) describe this method as the most useful and effective tool in the front-end design development process.

Co-creation sessions

The goal of these sessions was to discover the negative and positive aspects of passengers' long-haul flight experiences. Three groups were invited to participate. Each group consisted of 3-4 participants and a host (the host was always the same). In total, 10 participants aged 23-31 years participated in the study.

Printed templates showing a time line of the

flight were distributed. Visuals of positive experiences using stickers, post-it notes and pens were also employed, and a line was drawn to divide positive and negative feelings.

The session proceeded as follows:

1. The host welcomes the participants and asks them to read and sign the informed consent form.
2. The host gives a brief introduction to the study.
3. The participants are asked to recall their most recent long-haul flight. They are requested to draw their experiences on the template and write down the causes of their feelings on post-its.
4. The whole group discusses their experience, mentioning elements that had a significant impact on their experience.
5. The whole group divides the post-it notes into different categories, which are colour-coded with stickers.
6. Participants point out which elements they think will still be significant in 30 years and beyond.
7. The group discusses new elements that may improve their long-haul flight experience.
8. The host wraps up and ends the session.

Co-creation results

The topics mentioned during the sessions were divided into five categories: entertainment system, physical comfort, food, environment, and personal interaction. Figure 1 shows the number of times each category was mentioned during the session.

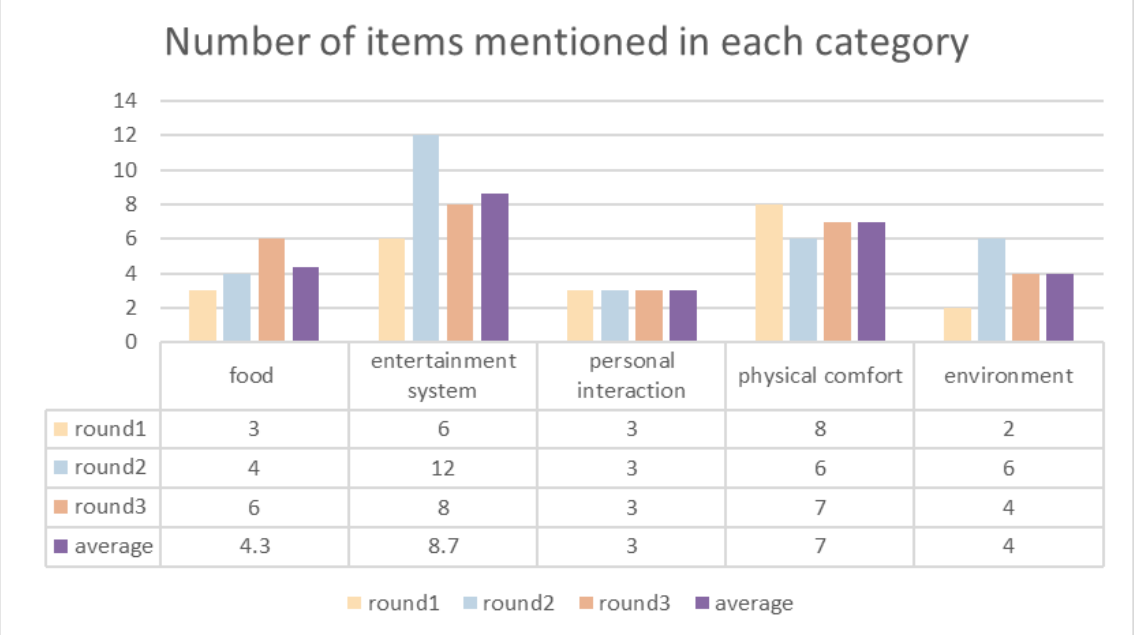


Figure 1 Number of items mentioned in each category in the three co-creation sessions (n=10)

Entert s seen as very important as th ying tim quite long. Although the tab on the chair in front enables people to h m and listen to music, the in-fli ertai t becomes boring after ar four hou passengers cannot find an eresting m al to watch or listen to, they get bored even faster. This situation is very likely to occur, as people have different tastes and the entertainment content cannot cater to the needs of everyone. Feeling bored also makes people more sensitive to their levels of physical comfort, especially the discomfort that is experienced due to restricted motion. In all

three sessions, however, it was mentioned that passengers do not want to perform strenuous exercise or exciting activities to prevent static postures. Low-intensity movement such as walking and stretching are deemed sufficient, as the intention is not to work out but to relax and alleviate any stiffness, reducing physical distress. Sleeping in an airplane can also cause physical discomfort. A lack of neck and waist support is the main reason for the low quality of in-flight sleep. During the sessions, participants mentioned that lying down can have the added benefit of reducing motion sickness. Likewise, a positive emotional reaction occurs when people are informed that the food service will start shortly, as expectations lift and they finally have something to look forward to. Most participants (7 out of 10) said that they spend more time on eating in an airplane than they do on the ground, as they consider it a form of entertainment during a long haul flight and hence want it to last longer. However, this does not mean they want to eat more. Conversely, passengers frequently have a low appetite. A possible reason, which was reported might be that the slower digestion and motion sickness may cause some stomach discomfort. Another reason is that many people would rather avoid going to the toilet during a flight. Airplane toilets are viewed as somewhat unhygienic, and standing in long queues for the bathroom is unpleasant. The queues are especially long after meals and before landing. People's quality of travel is also influenced by their surrounding passengers. Most do not want to interact with others, but space is limited and physical and/or verbal contact is sometimes inevitable. Being in the vicinity of children can also be a negative factor. Around two hours before landing is the most difficult time during a long trip. Physical discomfort is at its greatest, and passengers may feel unrested and already bored with the in-flight entertainment system. They want to escape the airplane, but there i latively long time before landing.

A total of 14 words expres positive f gs were used during the c eation se s (pleasant, relaxed, peac clear-mi d, energetic, thrilled, excited, sionate, fr y,

calm, joyful, adventurous, fascinated, powerful). Those with the highest frequency were: relaxed, peaceful and interesting. The words pleasant, friendly and calm were also mentioned more than once.

Online survey

A questionnaire was designed based on the results of the co-creation session and given to 128 subjects of different ages. It could be completed online using googledocs. Participants were asked to score five statements based on the negative elements summarised previously. Using a Likert scale from 1-7 (1= totally not agree; 7 = totally agree), participants had to choose five words for their desired experience from the 14 words emerging from the co-creation session. They also had to indicate the extent they want to be active and enga n soci eraction. In the third part of uestionn two words with opposite mea gs (acti nactive; social-isolated) were p ither side of a 7-point scale. Firs rticipa were divided into active, in e and ne categories. The same process was repeated for the social versus isolated. Genders and ages were also recorded for later comparison, and an open question on suggestions for improvement was added. Data were analysed as follows: averages and totals (the number of times a word is chosen) were calculated for age and gender categories. Participants were placed into two groups by age (20-40 and > 50) to see if older passengers have different preferences. T-tests were performed to compare different ages and genders, with $P<0.05$ considered statistically significant.

Online survey results

Figure 2 shows the averages for each age group. The graph indicates that older people are calmer and more tolerant (their answers are more neutral) than the younger group. The difference for the food service is very slight, while the biggest difference is in attitudes to children. Young people care more about this issue than seniors. This may be explained by the fact that seniors have experience of raising children, and are thus more tolerant of their behaviour. Results for lack of movement, however, reveal

that almost all old people would like more opportunity to move, while people age 20-40 care far less about this issue. Table 1 shows the T-test results for the different age groups. Statistical significance was found for all the statements except for the one about attitudes to children. However, there were no significant differences regarding gender.

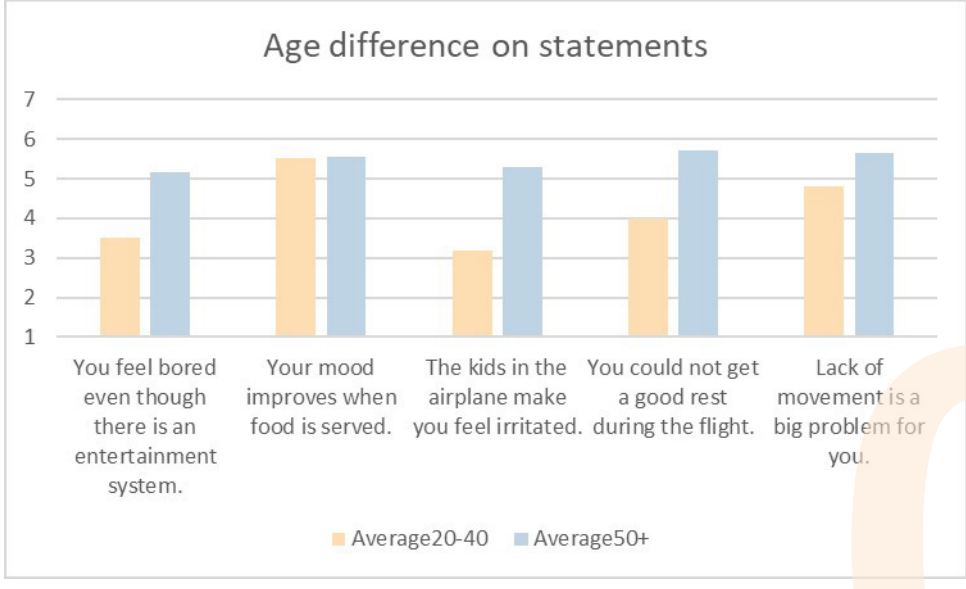


Figure 2 Average score on the 5 statements for the different age categories (20-40, n > 50, n=21)

Table 1 T-Test results for the five statements

T-Test on 5 statements	P	t	df	standard error of difference
T-Test on Age				
You feel bored even though there is an entertainment system.	<0.0001	4.7737	125	0.343
Your mood improves when food is served.	0.9368	0.0794	125	0.294
The kids in the airplane make you feel irritated.	<0.0001	6.0645	125	0.348
You could not get a good rest during the flight.	<0.0001	5.4121	125	0.315
Lack of movement is a big problem for you.	0.0114	2.5674	125	0.328
T-Test on gender				
You feel bored even though there is an entertainment system.	0.3481	0.9419	126	0.281
Your mood improves when food is served.	0.0665	1.8511	126	0.214
The kids in the airplane make you feel irritated.	0.0629	1.8765	126	0.289
You could not get a good rest during the flight.	0.9632	0.0463	126	0.259
Lack of movement is a big problem for you.	0.8018	0.2516	126	0.249

For the second part of the questionnaire, participants had to choose from the list of 14 words to describe a desirable experience. A tally w the number of times each wor s chosen e figure 3). Quality, relaxed, pea and plea were the most frequently ch words, w aligned with results from th creation se ns. This indicates that on-bo ctivities d t need to be intensive or thr . More p e aged 20-40 chose the word energetic compared to people over 50, while the inverse was true for the word calm. However, this difference is not typical. No significant gender differences were found in this area.

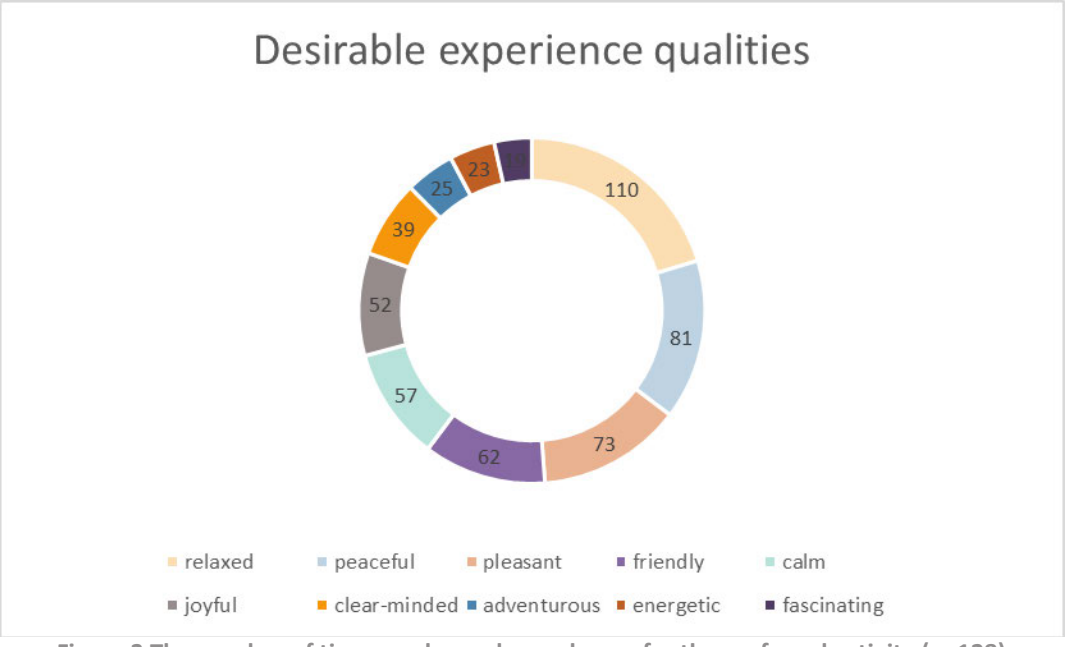


Figure 3 The number of times each word was chosen for the preferred activity (n=128)

Active-inactive and social-isolated results are shown in figure 4. These indicate that most people want to be both inactive and isolated in the aircraft. However, about one-sixth of respondents anticipated that their future airplane experiences would be more active and socially involved. A significant difference was found between the genders regardin vels of activity. Figure 5 shows that peopl 20-40 were more active than people o e level of preferred social interacti epen largely on gender, with males preferring m social engagement (see Figure 6).

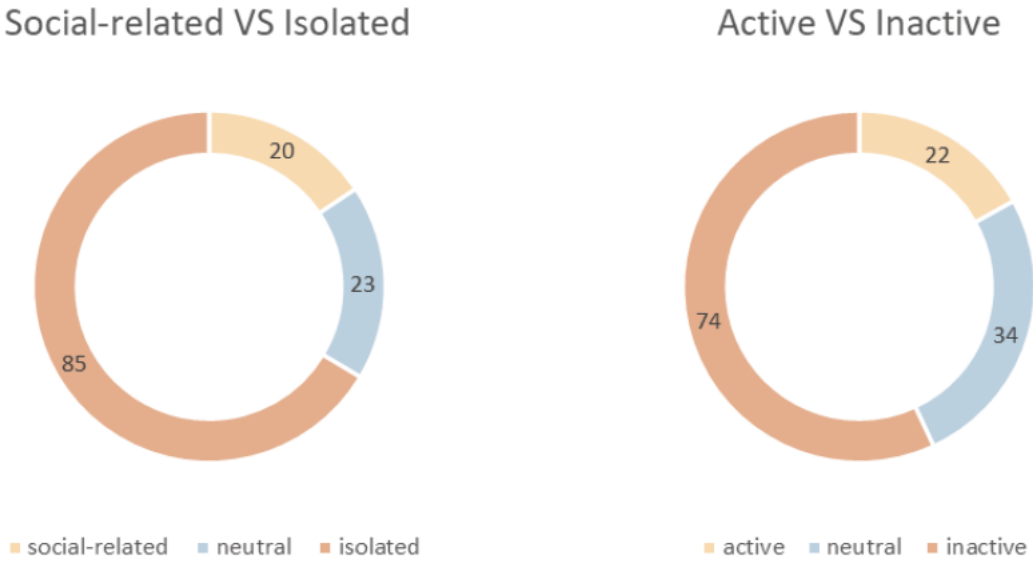


Figure 4 Number of participants for active vs inactive and social vs isolated (n=128)

Table 2 T-Test on preferable situation

T-Test on preferable situation	P	t	df	standard error of difference
T-Test on age				
Active level	0.0140	2.4936	125	0.329
Social level	0.0556	1.9318	125	0.330
T-Test on gender				
Active level	0.0511	1.9691	126	0.245
Social level	0.0044	2.9005	126	0.240

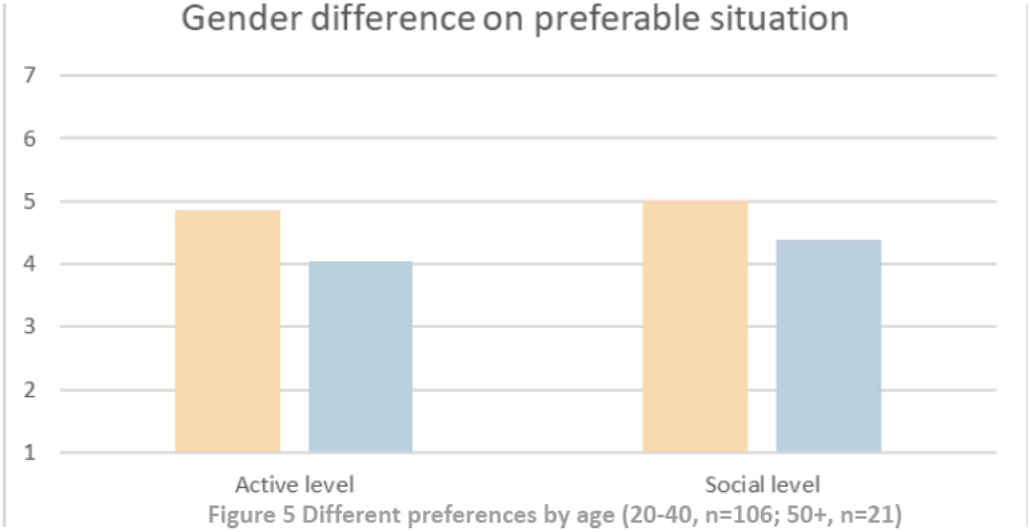


Figure 5 Different preferences by age (20-40, n=106; 50+, n=21)

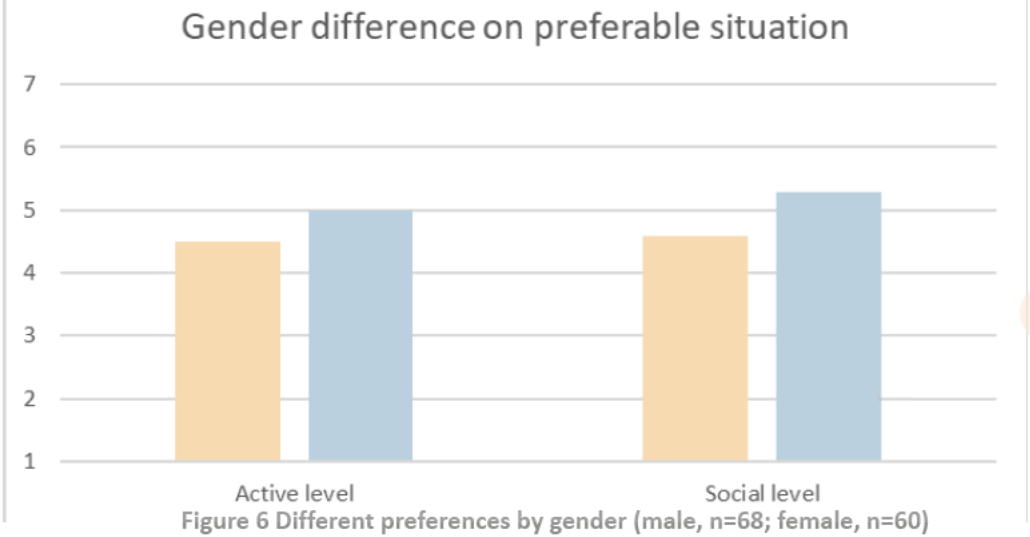


Figure 6 Different preferences by gender (male, n=68; female, n=60)

Conclusion

This research focused on the negative and positive experiences of passengers on long-haul flights. Results suggest that physical discomfort and feelings of boredom during the flight are the main causes for concern. Ideally, the future aircraft should be designed in such a way as to contribute to a relaxed, peaceful and pleasant experience. This would require the significant re-design of existing aircraft interiors. While social interaction and privacy should be both possible during a flight, the majority of passengers prefer privacy. Activities such as eating and going to the toilet have a significant impact on the overall experience, and should be taken into consideration in the design process. One of the reasons could b hat people can walk through the plane an shes them as is decribed by Hiemstra-v igt (2015).

Design take-aways

Based on the above results, the following are some suggestions for designers that may help to create a better passenger experience during long-haul flights:

1. More space for passengers to move around.
2. In-flight activities should focus on making people feel relaxed rather than excited. An interior should make it possible to have privacy; however, there should also be some space for passengers who enjoy social interaction. The ideal combination would involve higher levels of privacy.
3. Food service is seen as a relief from boredom. Extending eating times may help to improve the overall experience.
4. Children disturb other passengers. Adding a separate family area could be a solution that may also be appealing for families. Parents could interact with each other while their children play, allowing other child-free

passengers to enjoy a more peaceful trip.

5. Toilets are currently used both for bodily functions and as a place for washing hands/ faces and changing clothes. Some women also use the mirrors in the toilet to do their makeup. If a separate space could be found for these alternate uses, the waiting line might be shorter.

It is difficult to tackle all issues in this master thesis. In this thesis the focus is on the hygiene experience since the idea is to separate toilet and the hygiene space. It is an arbitrary choice, but a reason for choosing is this area should not be ignored although people spend a very small portion of their travelling time there. The quality of refreshing/ hygiene experience can also influence the overall flying experience.

Ch2.
Floor plan proposal for Flying-V

As the context is the flying V in the following paragraphs background information is given on the Flying V. Flying V, as a new type of aircraft will be in use in 40 years, many details of interior are not decided yet. Although engineers already gave a floor plan with a classical layout, there is still space to think out of box. A floor plan which is greatly passenger experience centred can be helpful to draw the blueprint of future aircraft cabin and make it more attractive to customers.

Requirements

From above-mentioned researches and the requirements from the client, the requirements for a general floor plan are summarized.

The original design from engineers (figure 7) made all the seats vertical to the wall which will create a 30-degree angle between the moving direction and seat direction. The influence on comfort is still unknown. Therefore, in our design the seats are positioned in the direction of flying. Additionally, some suggestion for the design of the interior are:

1. To cut waiting lines outside toilets, separate toilet activities from body care and make the basin activities easier, toilets and hygiene space should be separated. Change rooms should be provided.
2. More walking space should be provided. It would be good to reduce the barrier of reaching aisles by disturbing as less people as possible.
3. A sleeping cabin should be made for those who have low sleeping quality on seats.
4. A place for kids should be provided to improve the sleeping quality of other passengers.
5. It should be possible to carry a[illegible]nd 315 passengers in the new design.

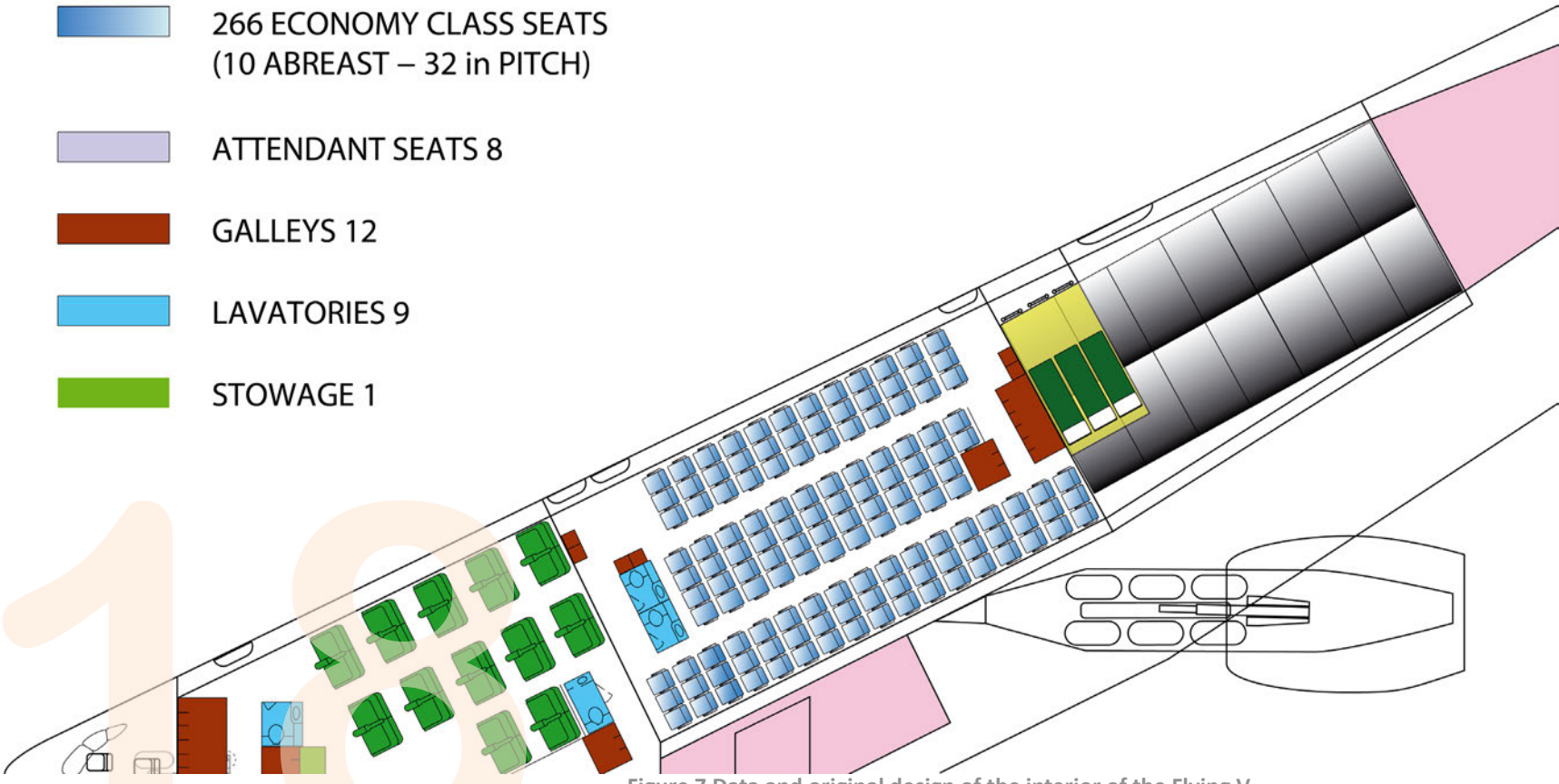


Figure 7 Data and original design of the interior of the Flying V

Ideal floor plan

The proposed floor plan can be found in figure 8. This design is made to meet the requirements mentioned in last paragraphs. In this design, all the seats (beds not included) are positioned in the flying direction of the airplane. Change rooms are provided. Toilets and body care space are separated. Additionally, there are clothing changing rooms foreseen. The reason why the hygiene space and change rooms are not together is that the privacy level and space needed to do the activities are different. Changing clothes is with a high privacy level. Baby caring devices will be equipped in these changing rooms with a foldable table. The height of change room, toilets and basin area in sleeping cabin can be a bit low for tall people since the highest place in sleeping cabin is 1.9-meter-high, but they can have a walk to the economy class cabin since it will not be a closed area. Besides the main aisles, the space beside walls is possible for people to have a walk as well as stand for a while. Most passengers can reach the aisle without passing any neighbours as the seats are 4 abreast, 80 passengers (all in economy class) need to pass 1 neighbour to reach the aisle. It is recommended to make the beds in blocks which can be easily replaced by cargo space. The amount of beds can be adjusted by the airlines in this way. The airline company can also decide whether they want one layer of beds or two layers. When there is only 1layer for all the blocks, the aircraft can carry 296 passengers. The number of passengers can increase to 342 if the space for cargo is not needed since the service to deliver baggage will reach more areas in the future.

Highlights

1.All the seats face the same direction of moving.

2.Toilets and basins are seperated.

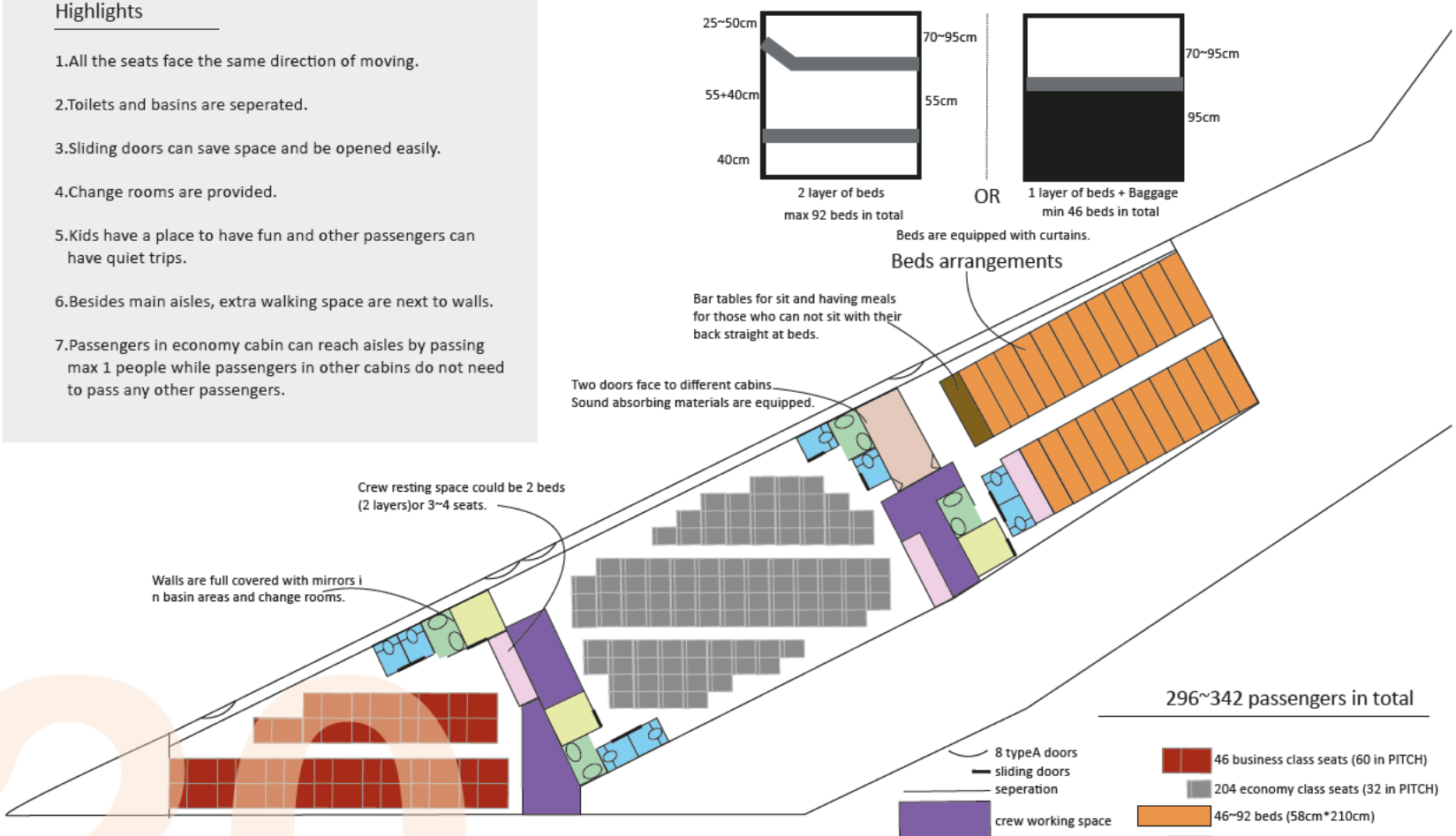
3.Sliding doors can save space and be opened easily.

4.Change rooms are provided.

5.Kids have a place to have fun and other passengers can have quiet trips.

6.Besides main aisles, extra walking space are next to walls.

7.Passengers in economy cabin can reach aisles by passing max 1 people while passengers in other cabins do not need to pass any other passengers.



P posed F or Pla or Flying-V

Figure 8 Proposed new floor plan

Ch3.
Research aim & question

As discussed above, the focus in this thesis is on the toilet, taking into account that long rows outside the toilet are seen as a problem, walking in the airplane should be stimulated and splitting toilet activities from body care activities is an opportunity for future flying. The toilet is an interesting place in the aircraft since a very small area is available in airplanes and it has multiple functions. Passengers will not spend too much time in toilets but it is hard to avoid going to a toilet during a trip, especially long trips. Everyone spends some time in toilets for different activities and long queues are quite common outside toilets. In the proposed floor plan, the toilets and hygiene space are separated to shorten the lines. Many activities, like make-up, shaving, washing hands, tooth brushing, can shift from toilets to a hygiene space. The design of the h pace then becomes important. In f NA A3 ovides a multipurpose room fo ssengers n to the toilets in the cabin (figure 9). This passengers who want to have a me-tim t not want to stay in toilets. The room c o be used for hygiene activities since a b is equipped. This affirms the need for this additional space. The idea of designing a new hygiene space is not only for the newly proposed floor plane of Flying-V but also with the intention of replacing 1 or 2 toilets in original floor plane made by the engineers since the sizes are similar. Because the engineers of the original floor plan copied the sizes from A350, the newly designed hygiene space can also be easily adapted to A350. The size of toilets in the new proposed floor plan is 90cm * 125cm. The numbers can be adjusted slightly to fit in aircraft with different layouts. Figure 10 shows how the size (orange block) could fit in the old design.

With this background information, work was done to answer the question: what are the pain points of current hygiene experience and what can be improved? The aim would be designing a hygiene space (toilets not included) that offers a satisfied and comfortable experience of refreshing.

Figure 9 ANA A380 multipupose room(Adrian Eugene Seet, 2018)

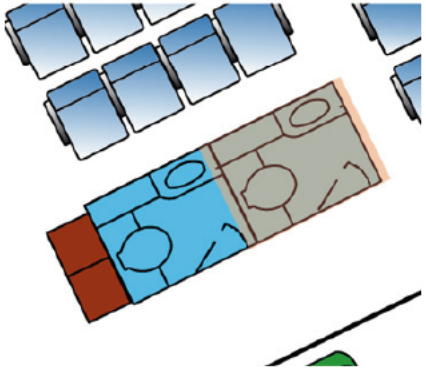


Figure 10 hygiene space fits in the old design

Ch4.
Research activities

Before performing the design activities, it is important to know the passengers' view and current experience of refreshing activities in airplane. Since there is no separated hygiene space in most of the aircrafts, the research activities were conducted focused on the hygiene/refreshing activities in toilets. There were two methods used in this part, which are co-creations (Sanders et al., 2012) and online survey.

Co-creation sessions

To answer the question on the elements that could potentially improve the experience of refreshing and hygiene activities in aircraft, co-creation sessions (Sanders et al., 2012) were set up to get an overall view on the pain points of current flying experience

The goal of this session was to define the main problems with hygiene/refreshing and understand what matters for the experience. In this study, 4 groups were invited to participate. Each group consisted of 4 participants and a host. In total, 16 participants (9 females and 7 males) participated in this study. All of them are master students from TU Delft.

The materials used were printed instructions to guide the process, paper, stickers, post-it notes and pens.

The process of the session was:

1. Researchers welcome the participants and give a short introduction.
2. Participants sign the consent forms.
3. Researchers guide participants to have a discussion on the questions: What do people do in lavatories in flight except excretion? What are the main problems when they having these activities in flight?
4. Participants do a cl (clas he problems).
5. Participants rank the importance o h categories.

Co-creation results

The results show that except excretion, a lot of activities can be done in the toilet around basin. These activities are considered as hygiene/refreshing activities in this project later. The results show that not all the facilities and tools provided are used for all the activities. The activities mentioned in the session are summarized into four categories: activities only need basin, activities only need mirror, activities need both basin and mirror, other/more complicated activities. Detailed classification can be found in figure 11.

Most activities mentioned above are considered as private activities and open space is desirable for these activities. Beside activities with facilities needed, activities without a functional aim were also mentioned. Staying in the toilet to be alone from the crowd for a while was popular answer. Also, sometimes passengers pretend to go to the toilet but actually they only want a walk. Disturbing neighbours is an awkward but necessary task for passengers sit in the middle and near windows when they want to reach aisles.

People have many complains about the around basin area in the toilet. Most people agreed that the space is too small and almost all the sizes in the toilet are not proper. The height of the basin is too low for adults. The basin is very small. The distance between water tap and the bottom of the basin is not comfortable when people put hands in. These small sizes make it hard for people to finish tasks properly and keep the area in good order, especially when there is turbulence. The storage place for personal belongings is needed since people sometimes need to carry some personal stuff such as phone and makeup. Some passengers do not like the cold light in the toilet since it is associated with a clinical room sometimes.

Since the hygiene/refreshing activities are now mostly happening in toilets, the general problems with toilet are also gathered. Firstly,

people think the toilet is dirty. Although sometimes the toilet is in good condition, they still feel it is not clean. There are many different containers and paper in the toilet, the lack of clear guidance can result in confusion of the use and arrangement. The door is also a problem. Several participants reported that the door is hard to operate and it is so thin that people stay outside can hear the sound inside. They do not feel their privacy is protected well in this way.

Figure 11 Activities aro in

Online survey

According to the results from co-creation, questions about ten aspects related to the experience of hygiene/refreshing activities are given in an online survey (a 7 scale questionnaire): standing space, possibility of sitting in front of the mirror, storage space for personal belongings, distance between tap and basin bottom, colour temperature of light, effort to operate the door, length of the waiting line, openness of the area, facilities provided, preference of having a change room or not. Participants need to score the level of satisfaction both when a feature is given and not given. The reason for this is to make it possible to apply the Kano model and define the quality of differ tures (Kano et al.,1984). 101 resp s inc g 58 female and 43 males we lected.

In the , qualities are divided into five cate :

Must-be quality: the features a product must have to meet users' demand. These qualities will not raise customers' satisfaction but lack of these qualities will result in dissatisfaction.

One-dimensional quality: giving these qualities results in users' satisfaction while not giving these qualities results in users' dissatisfaction.

Attractive quality: the qualities can raise customers' satisfaction when fully achieved but will not cause any dissatisfaction when they are not fulfilled.

Indifferent quality: the features that will not influence users' satisfaction level.

Reverse quality: when these qualities show in a product, dissatisfaction raises.

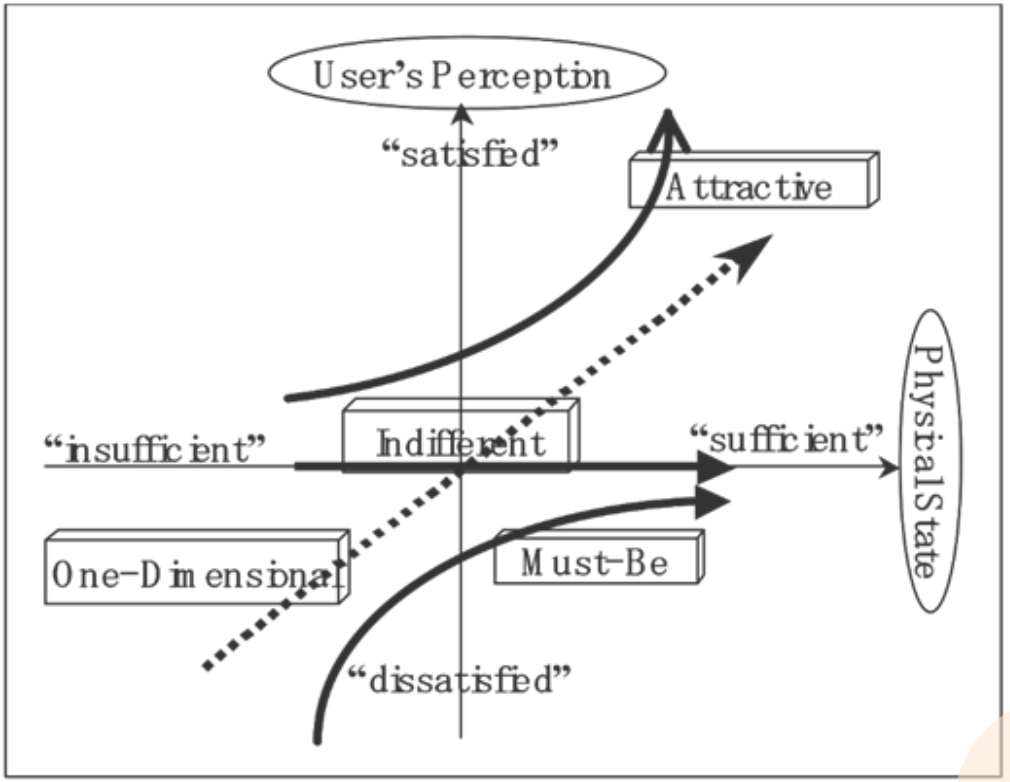


Figure 12 Evaluation Patterns of Qualities (Kano et al.,1984)

Following the principle of table 3 the ten qualities are analysed.

Table 3 Classification of quality elements into six patterns (Kano et al.,1984)

Phys. State	Sufficient			
Insufficient	**Perception**	dissatisfied	neutral	satisfied
	dissatisfied	*skeptical*	*must-be*	*one-dimensional*
	neutral	*reverse*	*indifferent*	*attractive*
	satisfied	*reverse*	*reverse*	*skeptical*

Online survey results

The qualities are defined with the application of the Kano model and the results are shown in table 4. The results base on average and amount are the same. However, when the genders are separated, difference shows up. The need of female and male are contradicting on whether they can sit in front of a mirror. Female does not want to sit in front of a mirror but men do want to. This would be a problem to make a decision in later design. There is also a difference in the view towards change room but this will not be a design problem since as long as the change room is provided, both female and male are satisfied. The distribution can be found in figure13.

Table 4 Quality classification

	Average	Preference of most people	Preference of most female	Preference of most male
Larger standing space	one-dimensional	one-dimensional	one-dimensional	one-dimensional
Sit in front of mirror	one-dimensional	one-dimensional	reverse	one-dimensional
Place to hold personal belongings	one-dimensional	one-dimensional	one-dimensional	one-dimensional
Distance tap-sink	one-dimensional	one-dimensional	one-dimensional	one-dimensional
Warm light	one-dimensional	one-dimensional	one-dimensional	one-dimensional
Easy door	one-dimensional	one-dimensional	one-dimensional	one-dimensional
Less people waiting	one-dimensional	one-dimensional	one-dimensional	one-dimensional
Open space	reverse	reverse	reverse	reverse
Facillities	attractive	attractive	attractive	attractive
Change room	one-dimensional	one-dimensional	one-dimensional	attractive


Female participants
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Male participants
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
male_larger standing space
male_sit in front of mirror
male_place to hold personal...
male_distance tap-sink
male_warm light
male_easy door
male_less people waiting
male_open space
male_facilities
male_change room
must-be
one-dimensional
reverse
indifferent
attractive
others

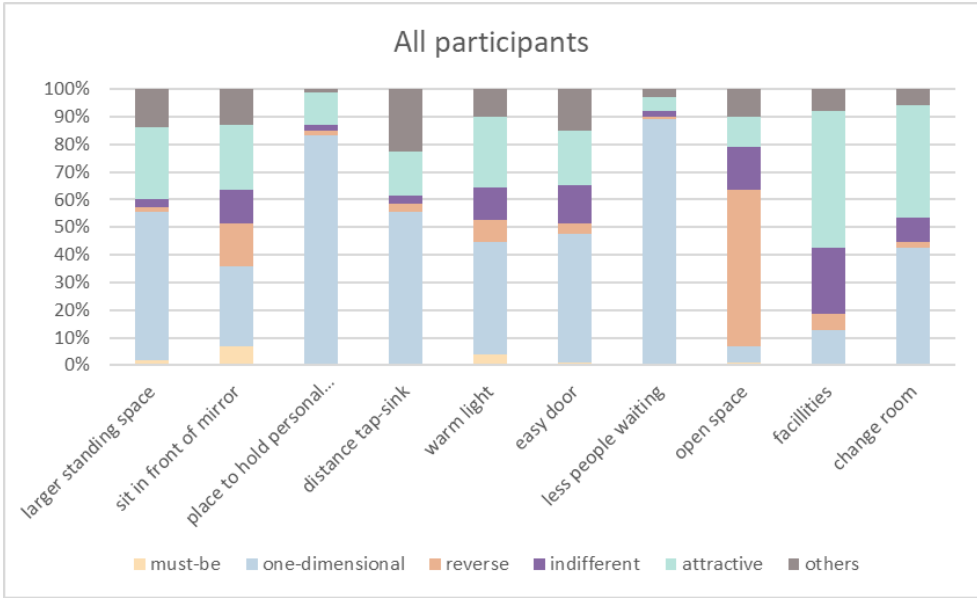


Figure 13 Distribution of different qualities

To further study the different needs of female and male, a t-test was conducted. The results can be found in table 5. Significant differences between female and male are found on the aspects standing space, the possibility of sitting in front of a mirror and the length of waiting line. All the significant effects are found when the qualities are given, which means there is no difference on the dissatisfaction when these qualities are not given but female are more satisfied than male when they have larger standing space and shorter waiting line. The contradictory between genders on whether they can sit in front of a mirror is confirmed in the t-test but care should be taken in interpreting the data since it is not so important whether women can sit in front of a mirror or not. They are not satisfied, but the average of the female group is very close to neutral when there is a seat. Tests on this aspect should be done in later experiments with VR technology.

Table 5 T-test results (n=101, female= 58, male=43, significant items are marked in yellow)

	female avg	female stdev	male avg	male stdev	t	df	rd error of diff	p
larger standing space	6.500	0.926	5.837	0.754	3.8432	99	0.173	0.0002
same standing space	3.603	1.123	3.791	1.355	0.7615	99	0.247	0.4482
sit in front of mirror	3.966	1.498	4.814	0.982	3.2309	99	0.262	0.0017
stand in front of mirror	3.655	1.409	3.349	1.089	1.1851	99	0.258	0.2388
place to hold personal belongings	6.052	0.736	5.837	0.836	1.3697	99	0.157	0.1739
no place to hold personal belongings	2.724	0.933	2.651	0.842	0.4051	99	0.18	0.6863
larger distance tap-sink	5.448	0.994	5.140	1.125	1.4555	99	0.212	0.1487
same distance tap-sink	3.500	0.978	3.256	1.026	1.2141	99	0.201	0.2276
warm light	4.966	1.228	5.023	0.801	0.2652	99	0.215	0.7914
cold light	3.702	1.149	3.512	0.960	0.88	99	0.216	0.381
easy door	5.241	1.031	5.372	1.024	0.6632	99	0.207	0.5281
same door	3.621	1.073	3.395	0.929	1.1071	99	0.204	0.2709
less people waiting	6.155	0.812	5.814	0.852	2.0435	99	0.167	0.0437
same amount of people waiting	2.310	1.012	2.535	0.960	1.1291	99	0.199	0.2616
open space	3.649	1.420	3.767	1.065	0.4576	99	0.258	0.6483
close space	4.877	1.196	4.488	0.935	1.7687	99	0.22	0.08
facillities	4.983	1.249	4.930	0.704	0.2502	99	0.212	0.803
no facilities	4.069	0.746	3.884	0.544	1.3766	99	0.134	0.1717
change room	5.862	0.945	5.698	0.939	0.8647	99	0.19	0.3893
no change room	3.500	0.941	3.674	0.808	0.9748	99	0.179	0.332

Conclusion

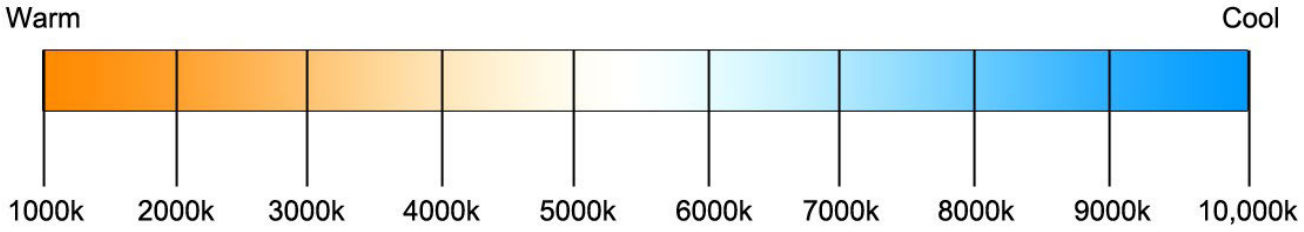
It seems that the aspects larger standing space, place to put personal belongings, larger distance between tap and basin, warm color, easy door, fewer people waiting and proving change room are important in designing the area for refreshing/ hygiene since these can result in the growth of the comfort of refreshing/ hygiene activities. Separation of toilet and hygiene/refreshing space might be a solution for reducing the waiting line. Open space can result in the reduction of satisfactory which means the final design should be a closed space. More facilities given can be extra values added. The aspect of sitting in front of the mirror is not clear and need to be studied. Also, for four aspects, warm color of the light, the distance between tap and bottom of the basin, and facilities, the preferable setting and range for each aspect is not clear. Thus, a study to compare different conditions of each aspect is planned.

Ch5.
Exploration of different qualities

To define the design direction some parameters and ideas will be explored further and passenger preference is studied. Four aspects are studied because the range of each aspect is still not clear. These are color temperature of the light, distance between tap and basin bottom, storage space for personal belongings and facilities provided around basin. To get a rough passenger preference materials and visual references from different websites are used to form a questionnaire consisting of 5 multiple choice questions. Interviews are done to understand the reason of the participants choice. Data of 12 participants are gathered and the two most preferable parameters/ideas in each aspect will be tested and compared in a VR environment. Additionally, a basic rough design is also made in this stage.

Color temperature

According to the results from the previously mentioned survey, warm light should be used in the newly designed hygiene space. Usually, warm light is considered to the light with a colour temperature lower than 4000K. Figure 14 shows that the light becomes warmer when color temperature decrease. A proper picture (figure 15) shows the different color temperature is found to gather the first impression.



1,700k	Match flame
1,850k	Candle flame, sunset/sunrise
2,700k - 3,300k	Incandescent lamps
3,000k	Soft (or Warm) White compact fluorescent lamps
3,200k	Studio lamps, photofloods, etc...
3,350k	Studio “CP” light
4,100k - 4,150k	Moonlight
5,000k	Horizon daylight, tubular fluorescent lamps or cool white/daylight compact fluorescent lamps
5,500 - 6000k	Vertical daylight, electronic flash
6,200k	Xenon short-arc lamp
6,500k	Daylight, overcast
6,500k - 10,500k	LCD or CRT screen

Figure 14 Diagram of color temperature (Flexineon Australia, 2019)

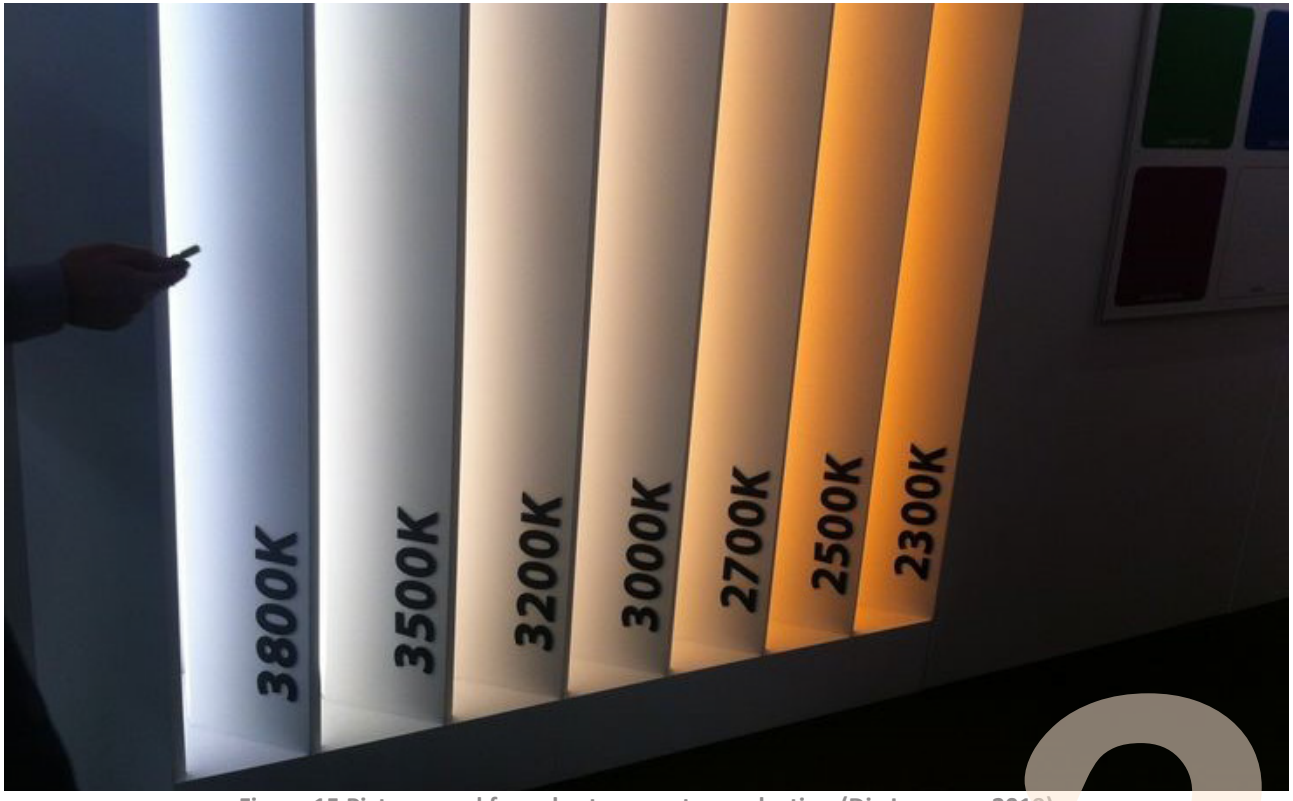


Figure 15 Picture used for color temperature selection (Diy Lampen, 2019)

Distance between tap and basin bottom

The average hand width in figure 16 is 84mm(male) and 74mm(female)(The average body，2014). Based on this, the first idea for different distances between water tap and bottom of the basin was designed: 16cm, 20cm, 24cm, 28cm, 32cm in figure 17.

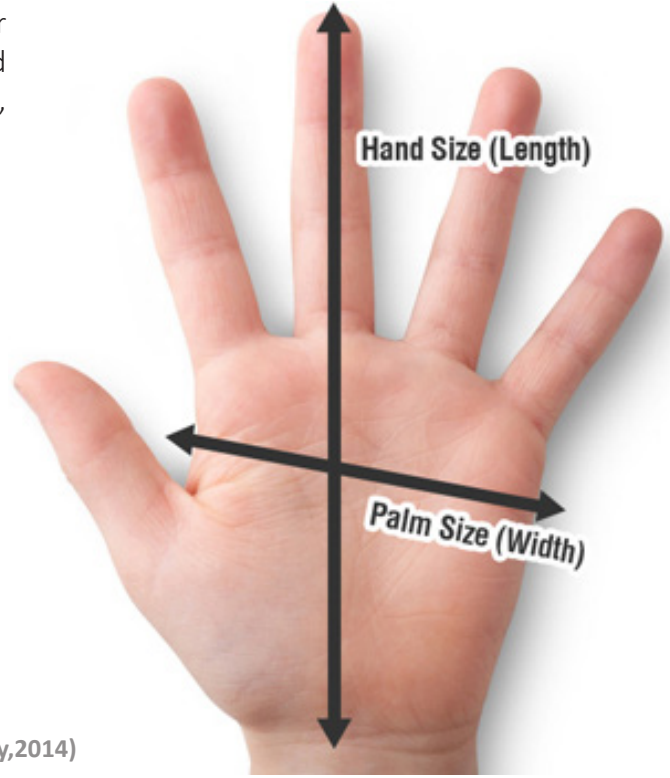


Fig 6 Measure of hand size (The average body,2014)

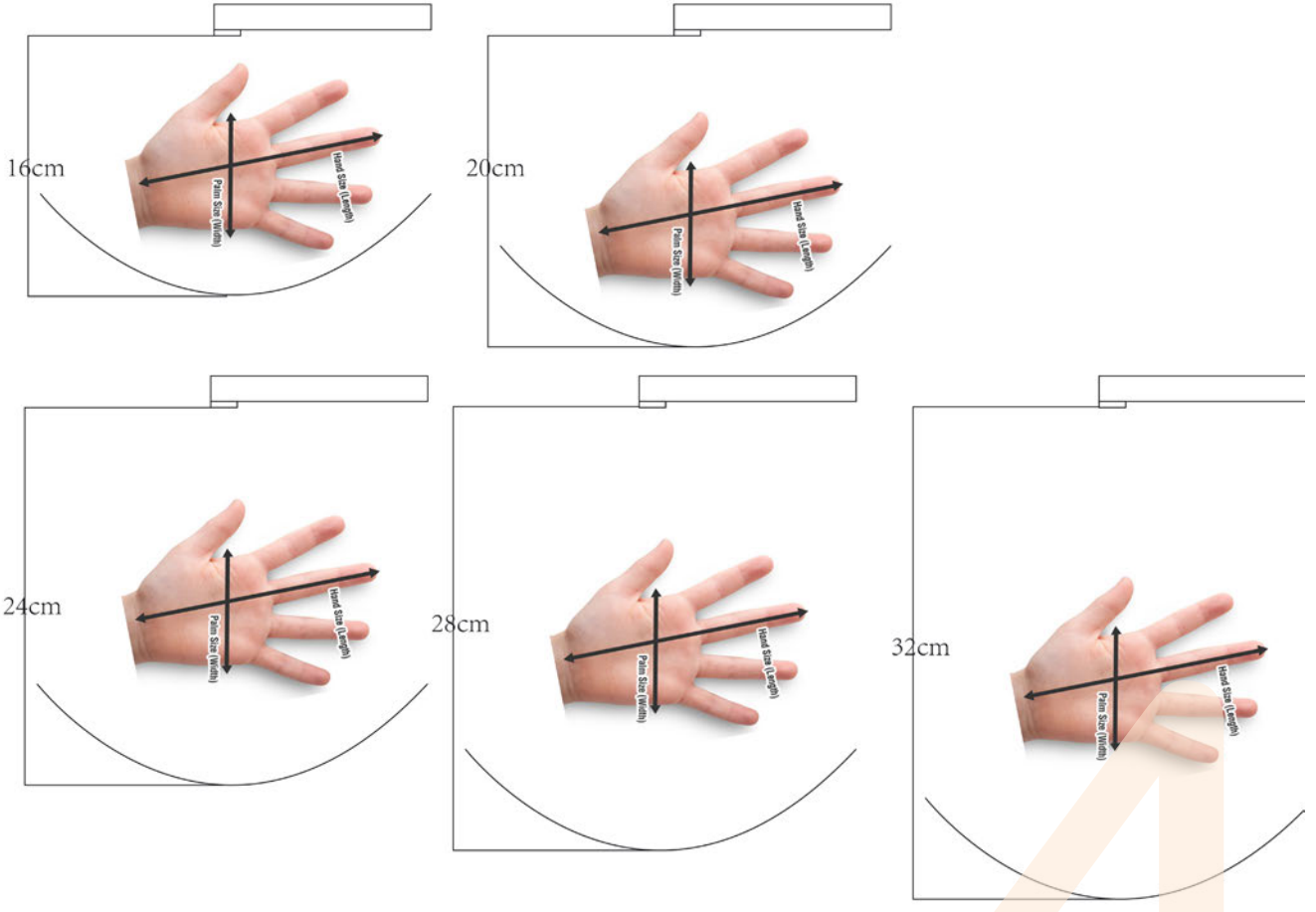


Figure 17 Different distance between tap and basin bottom

Storage space for personal belongings

In figure 18, four ideas for storage of personal belongings are presented. In each idea, shelves and hooks are both provided. In idea A, a storage space with a separation wall outside which can keep things inside dry is provided. In idea B, the shelf is made into a semi-closed container. In idea C, two shelves with different height are made and a bar to hang objects attached to the shelf. In idea D, three shelves with two different heights are given. Hooks are provided at both sides.

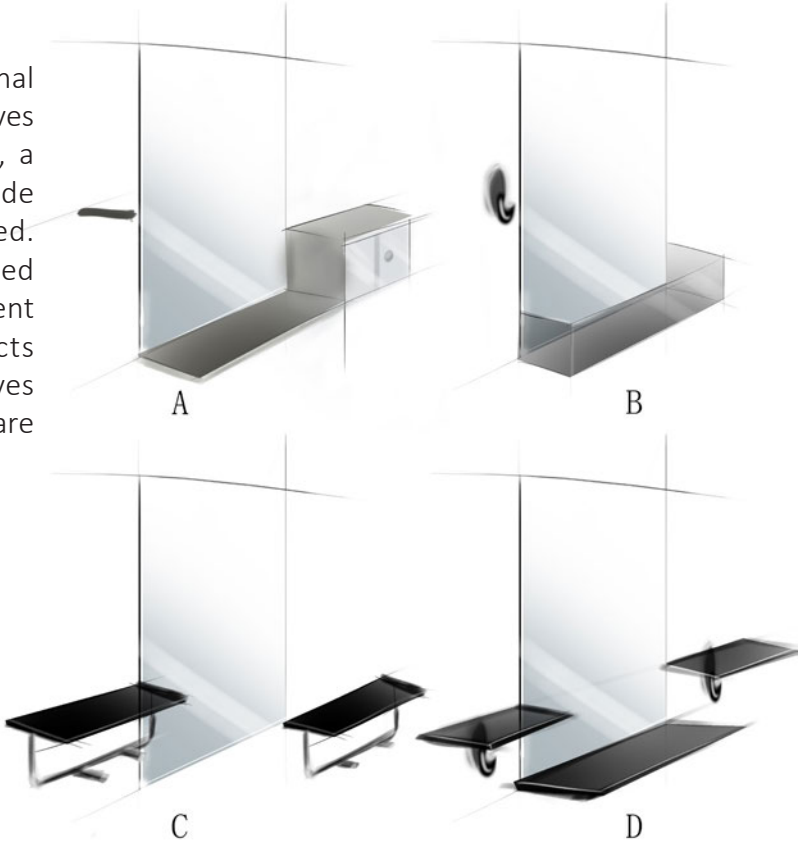
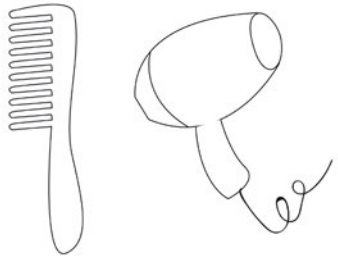


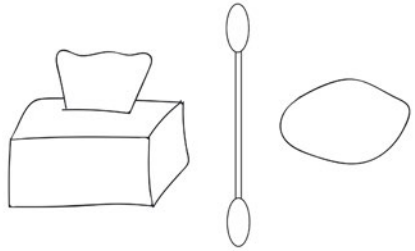
Figure 18 Ideas of storage place for personal belongings

Facilities

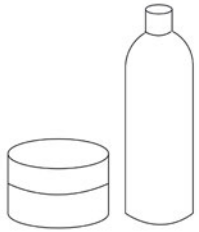
What people usually need for hygiene and personal care is considered and based on that objects are defined and divided into different groups base on functions. The main concern of whether to provide a certain object is about privacy since people might not want to share this with others. Products related to personal care include product to be used for the face, the hair and etc. and are provided as options here. Figure 19 shows the options.



A. comb+hair dryer



B. cleansing wipes+cotton buds+cotton pads



C. hand cream+hand soap

D. all of above

Figure 19 Options on facilities

Summary of the preferences for later test

It is too much to test all options, therefore a selection was made and the two to the researchers 'opinion most preferable parameters/ideas are selected and shown in table 6 as conditions for the test later. Most people did not give very clear reasons of their choice but relied on their intuition quite a lot.

Table 6 Study variables and comparisons(n=12)

Variables/aspects	Conditions	
seat	With seat	Without seat
Color t er	3500K	3000K
Di ce betw p and ba	24cm	28cm

Storage place for personal belongings		
Facilities		

Location of the tap

For the location of the tap DINED was used as it contains information on reach envelope and anthropometric. It is important that the tap is reachable and comfortable and there is enough space between tap and basin. DINED data were gathered from 6 groups: age20-30 while height>175cm, age20-30 while height<175cm, age 50-74 while height>170cm, age50-74 while height<170cm, age 75+ while height>165cm and age 75+ while height <165cm. Figure 20 shows the reach envelopes for each group. To make sure everyone can reach the tap, the 5-percentile data of the maximum reach is used. To make sure most people feel comfortable, the tap should be at the area that the comfortable reach for each group covers. The yellow part in figure 21 shows the possible location of tap. Considering of children's height, the location of the tap is decided to be the lowest point of this area, which is (-70cm, 118cm). However, the data from DINED did not cover all the possible passengers. People age 30-50 and children were not included.

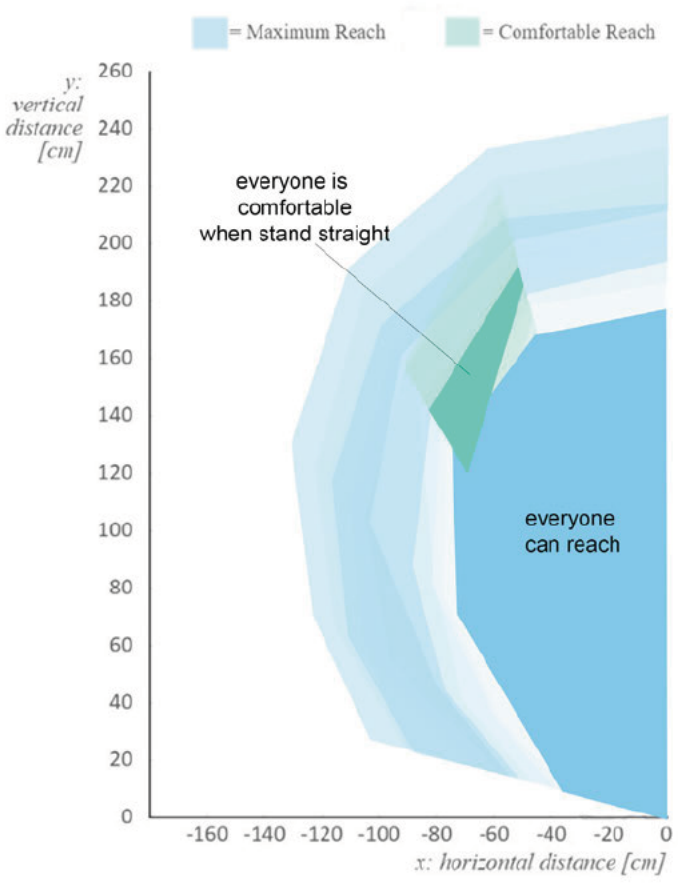


Figure 20 Comfortable area when people standing straight

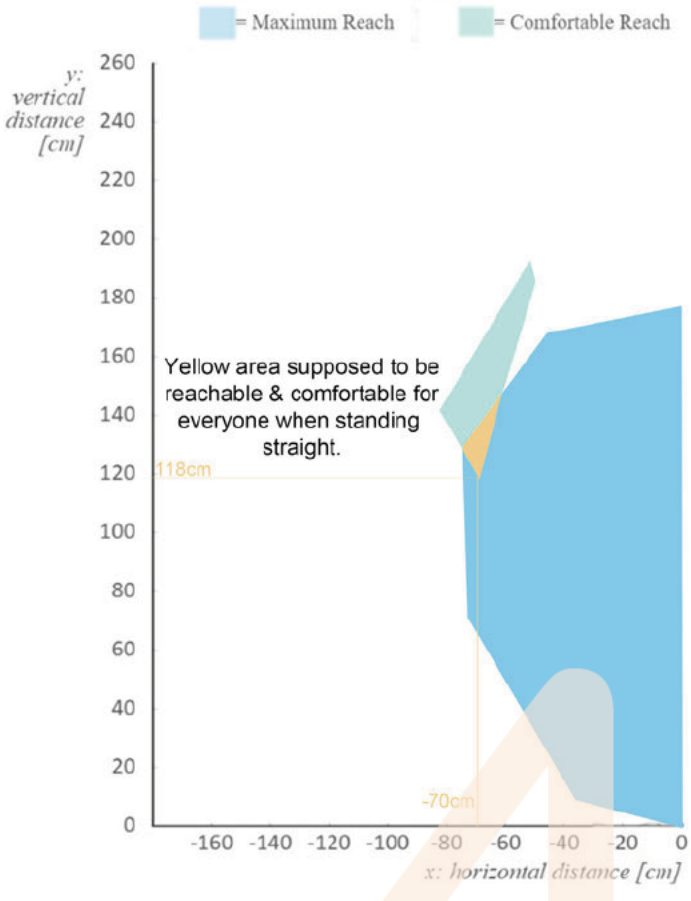


Figure 21 Loc n of tap

Basic setting

The location of the tap is comfortable for adults but might be too high for young children since the average height of 3-year-old girls and boys are 94cm and 95.2cm. One of the solutions could be a flat basin to enlarge the field of vision. With current technology, it is possible to make a basin with a thickness around 8cm to 10cm. Another solution could be a block beside the basin to facilitate that children can stand on this block. The distance between tap and the bottom of basin is usually between 20cm to 30cm which means the height of the basin bottom will be 88cm to 98cm. The upper surface of the basin will be 96cm to 108cm. Considering the height of children, an additional 30cm should b h for them to see everything abo e bas he length in the standing dire n (short e of the block) is decided to be 2 which ze 40 to make sure all the childre d on it. Using the mirror will not proble ecause of the height since th will be two length mirrors. The full-length mirror is for people to have a simple check of their dressing and other activities without a need of water. Loth & Molenbroek (2011) addressed that mirrors can raise the perception of cleanness. However, the room will not be fully covered by mirrors since too many mirrors may cause daze and people do not want their faces to be reflected by the mirrors in front of others since the activities can be considered as private. The space between people and the tap should be at least 70cm for people to adjust themselves to achieve comfortable experience according to the location of tap. Since the short edge of the room will be around 90cm, the length of the tap is decided to be 15cm. To reduce touching chances in the hygiene space, the tap should be inducted. Sliding doors will be used in this design since they are easy to operate and can be used to create a separation from the open space. After considering all above and trying to make the most use of the space, the basic setting and structure of the room will be used in the experiment are shown in Figure 22.

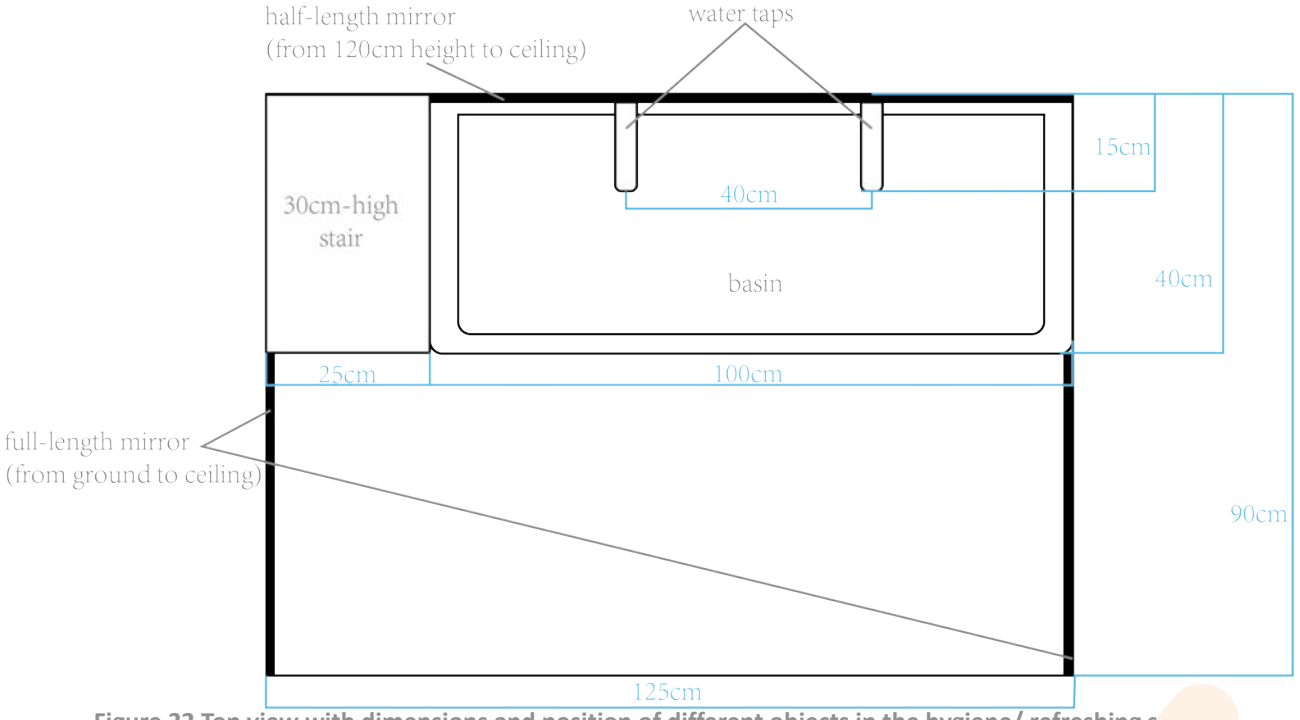
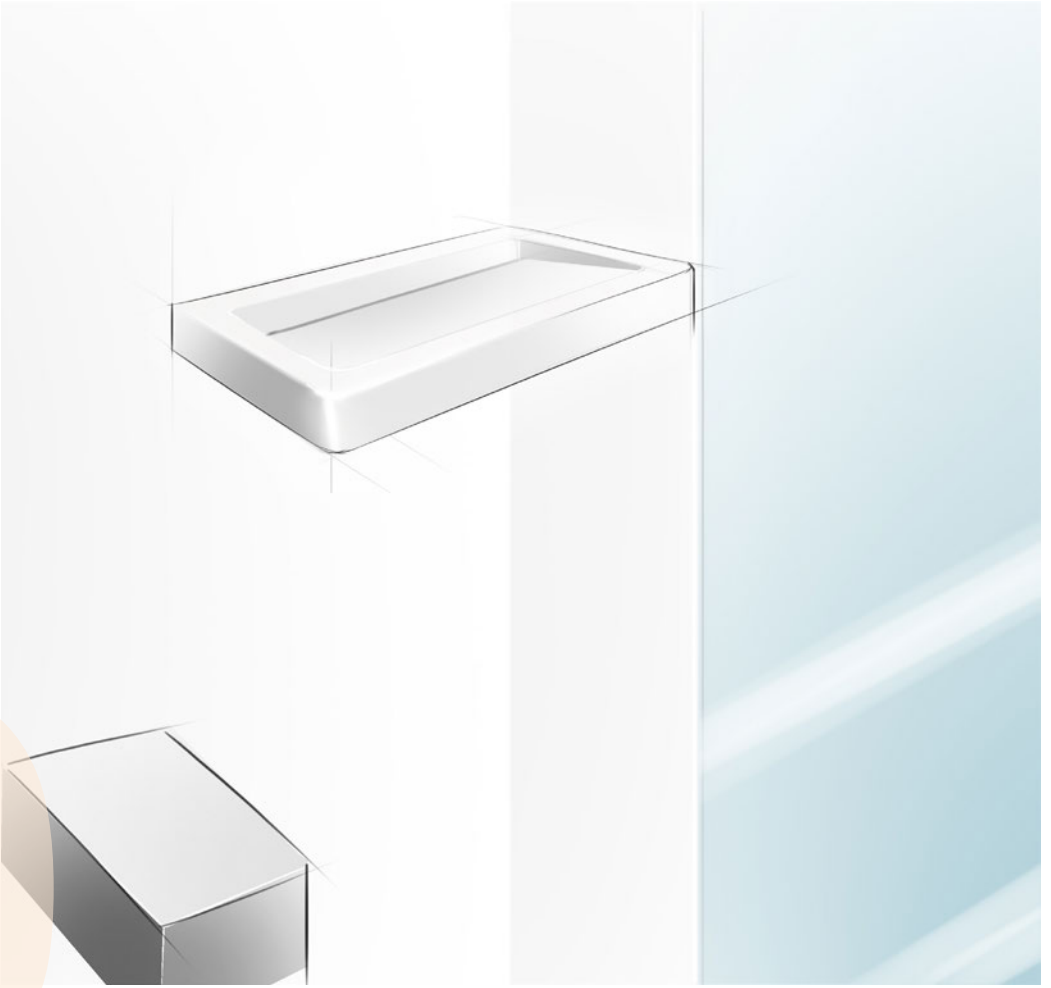


Figure 22 Top view with dimensions and position of different objects in the hygiene/ refreshing s



F 23 Sketch of
b n the space

Ch6.
Design element test

To make a substantiated choice for designing the hygiene area, a VR test including 28 participants was conducted. There are two aims for the study. One is to evaluate different conditions to make better design decision. Another is more a scientific question to study if there is a difference in perception between showing the alternatives in design in VR or on a desktop. A 7-point scale was used to evaluate the different conditions and every participant had to fill in Pre-SSQ and Post SSQ questionnaires, to study the influence of the VR experiment. During the experiment, participants were required to be quiet and give scores by gesture so participants with different display media would not influence each other. A 1 to 1 scale space was made by separating the environment with cardboard walls.

Experiment procedure

Different conditions were modelled and exported to Unreal engine. To make sure the orders of the different conditions will not influence the results, two conditions in each element were shown in different orders every time. Also, a baseline condition was added before each condition was tested. The exposure time of baseline was 20 seconds while the exposure time of each condition was 40 seconds. The exact experiment process of one order can be found in table 7. From the top to the end of the table shows the experiment process from start to the last second. The experiment was done in pairs. When a participant is in the VR environment, the other participant watches the screen which shows exactly the view people have in the VR environment. The complete procedure is:

1. Researchers welcome the participants.
2. Participants sign the consent form.
3. Participants fill in Pre-SSQ questionnaire.

4. Researchers lead participants to the experimental area and set up the program.
5. Researchers give an introduction to the experiment.
6. Researchers run the experiment program.
7. Participants fill in Post-SSQ questionnaire.
8. Break for 1 minute.
9. Participants fill in Pre-SSQ questionnaire.
10. Participants change display media and researchers run the experiment program.
11. Participants fill in Post-SSQ questionnaire.
12. Short discussions for comments and suggestions.

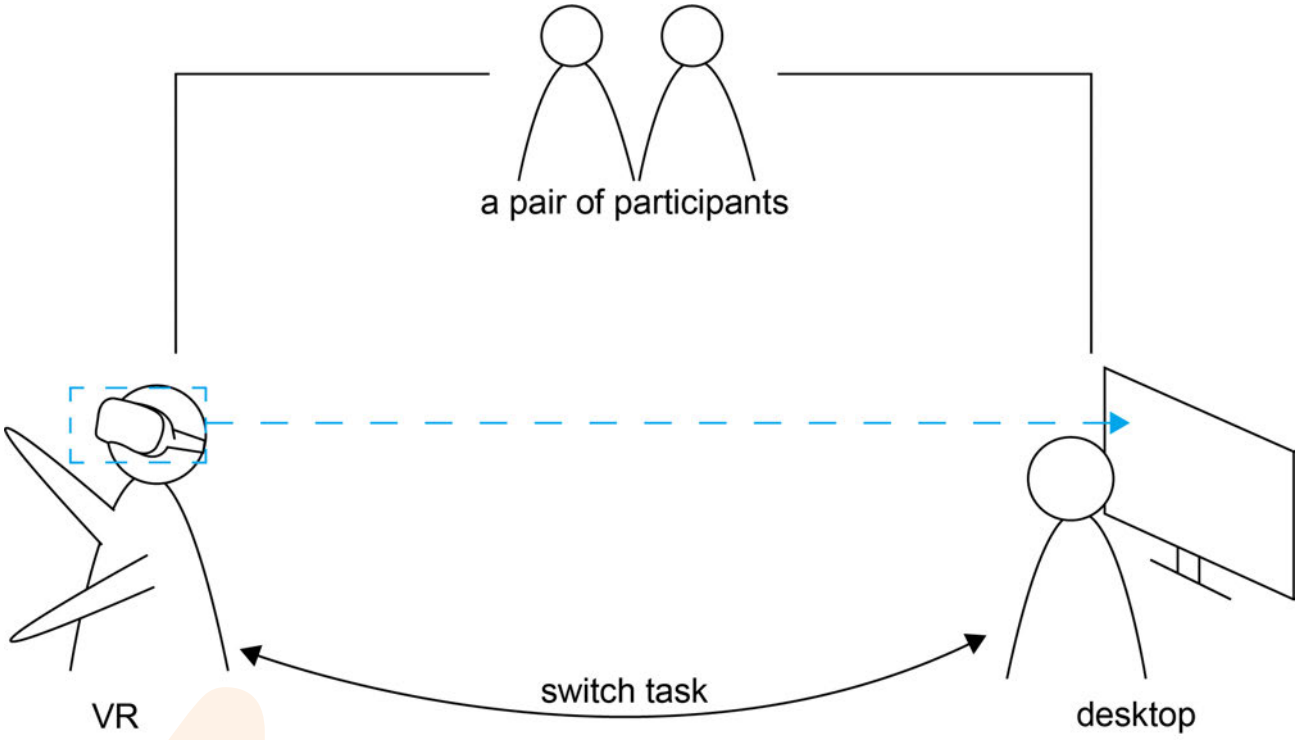
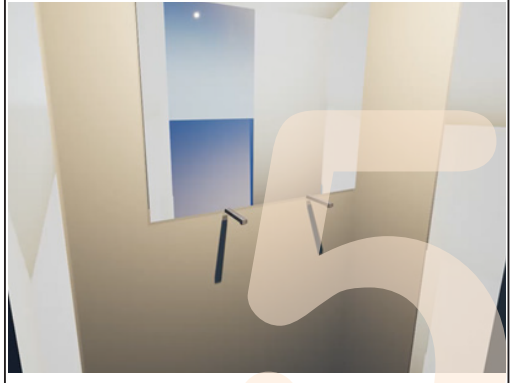


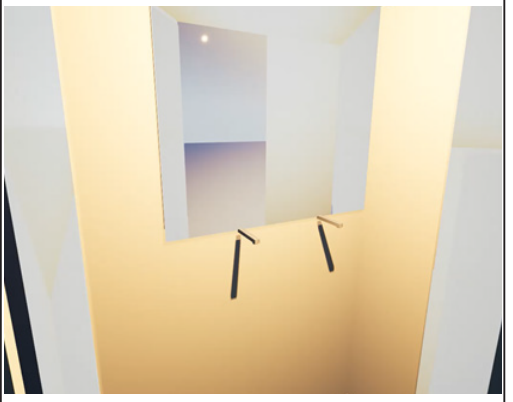
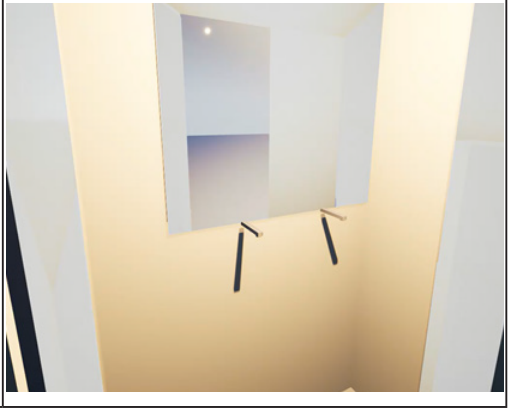
Figure 24 Experiment in pairs

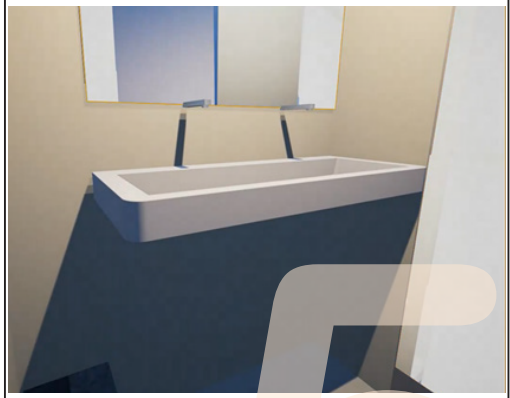
Figure 25 Experiment in process

Table 7 experiment program process

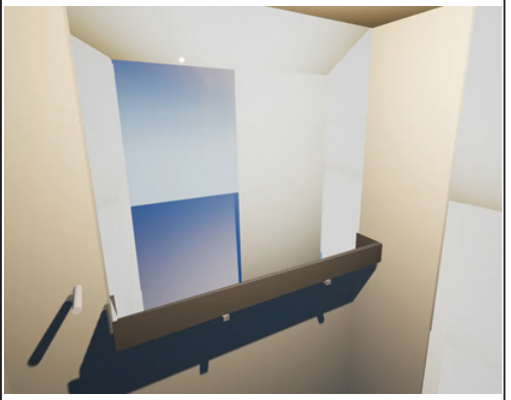
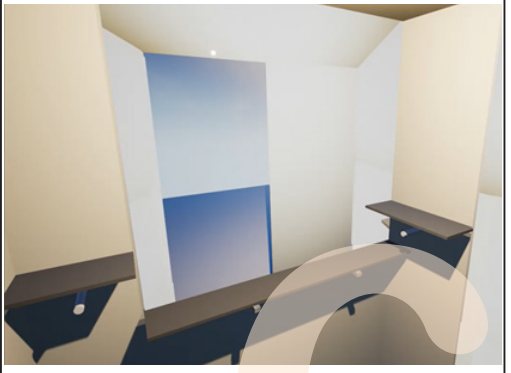
Time period	Condition	Scene
0-20s	Baseline	
0-60s	Condition-with seat	

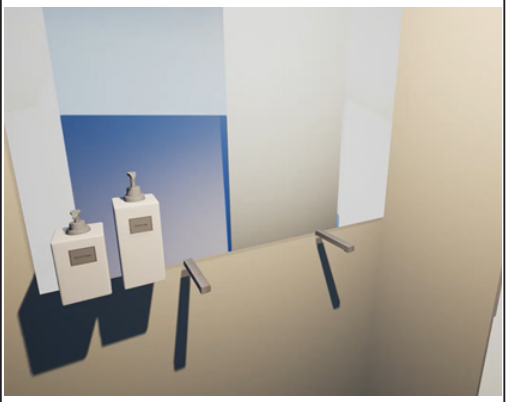
60-100s	Condition-without seat	
100-120s	Baseline	

120-160s	Condition-light tempreture:3000K	
160-200s	Condition-light tempreture:3500K	

200-220s	Baseline	
220-260s	Condition: 24cm between tap and basin	

260-300s	Condition: 28cm between tap and basin	
300-320s	Baseline	

320-360s	Condition: storage design 1	
360-400s	Condition: storage design 2	

400-420s	Baseline	
420-460s	Condition: hand cream & hand soap provided	

460-500s	Condition: hand cream, hand soap, cleansing wipes, cotton swabs, cotton pads, comb & hairdryer provided	

Experiment results

Quantitative results

The score of each condition in the VR environment, desktop display and the average of the two media for each participant were compared. Only three pairs of conditions seat, light temperature and storage are normally distributed when calculating the average of two media. No pairs are normally distributed when calculating data from VR environment or desktop display. T-tests were done on the normally distributed pairs and Wilcoxon ranks were analysed for the rest. The pairs are considered to be different when Sig.<0.05.

Table 8 quantitative analyze results

Condition pairs	Average	Analyze methods	Sig.
VR_ with seat	3.85	Wilcoxon	0.056
VR_ no seat	4.67		
VR_ light 3000K	4.32	Wilcoxon	0.053
VR_ light 3500K	4.82		
VR_ 24cm from tap to basin	5.41	Wilcoxon	0.036

VR_ 28cm from tap to basin	4.78		
VR_ storage condition 1	4.07	Wilcoxon	0.021
VR_ storage condition 2	4.86		
VR_ condition with less facilities	4.46	Wilcoxon	0.002
VR_ condition with more facilities	5.64		
Desktop_ with seat	3.62	Wilcoxon	0.185
Desktop_ no seat	4.04		
Desktop_ light 3000K	4.36	Wilcoxon	0.433
Desktop_ light 3500K	4.54		
Desktop_ 24cm from tap to basin	4.44	Wilcoxon	0.231
Desktop_ 28cm from tap to basin	4.15		
Desktop_ storage condition 1	3.75	Wilcoxon	0.015
Desktop_ storage condition 2	4.71		

Desktop_ condition with less facilities	4.57	Wilcoxon	0.063
Desktop_ condition with more facilities	5.43		
General_ with seat	3.54	T-test	0.020
General_ no seat	4.25		
General_ light 3000K	4.34	T-test	0.087
General_ light 3500K	4.68		
General_ 24cm from tap to basin	4.75	Wilcoxon	0.090
General_ 28cm from tap to basin	4.41		
General_ storage condition 1	3.91	T-test	0.009
General_ storage condition 2	4.79		
General_ condition with less facilities	4.52	Wilcoxon	0.009
General_ condition with more facilities	5.54		

Table 9 Significance status

	VR data	Desktop data	General data
Seat			Significance found
Light temperature			
Distance from tap to basin	Significance found		
Storage condition	Significance found	Significance found	Significance found
Facilities	Significance found		Significance found

According to the tables above, no significant difference was found between the different light temperature conditions, which means 3000k and 3500k will not change a lot in people's satisfaction and comfort. Significance was found on other aspects. Significant differences were found on at least one calculation method and the difference could be assumed to exist.

Qualitative results

Qualitative data were collected after experiments. Some suggestions and comments were summarized. For instance, it was mentioned that the seat is good to have when there is turbulence but it makes the space smaller. Also, a seat can make people stay longer. Another remark was that the second storage is nice since it provides more space to put personal belongings but a small edge could make it better considering the turbulence. Most facilities are useful but people tend to bring their own comb with them. The block at side for children to stand on is too high. Towel and garbage bin should be added to the final design.

Ch7.
Final concept

The final concept was built based on the results of previous design element test. According to the results, the final concept was decided to be a combination of the conditions: no seat, light temperature 3500K, 24cm from tap to basin, storage 2 and more facilities provided. However, some changes were made after the combination.

Firstly, the comb is no longer provided since people do not want to share the comb with strangers and prefer to use their own. Secondly, the block for children is changed into two stairs with 15cm for each to make sure kids can climb easily. The board on the left above the stairs which may make it hard for kids to stand straight is cancelled and the hairdryer is moved to this side to avoid occupying the space on the shelf. At the e, it enables kids to use the haird An ed ith a height of 3cm is added to helves t event falling when there is ulence. T ook is moved to a more re ble place. y, towel and garbage bin ar ed below basin. Usually, the towel is ed above basin but if you pick up a towel high, you lift your hands and water of the hand will flow into the sleeves. So, it was decided to locate the towel at a lower position in this new design. The final concept can be seen in figure 26.

Figure 26 Final concep
refreshing/hygiene s from
different perspectiv

Ch8.
Concept evaluation

To evaluate whether the final concept of the hygiene area has the potential to improve the experience, 33 people including 14 females and 19 males ageing from 18 to 45 years were invited for a test. They needed to fill in a score on a 7-point scale (1 is very not comfortable and dissatisfied while 7 is very comfortable and satisfied) on both general comfort and satisfaction and separate functional parts. During the experiments, participants were asked to imagine themselves in a long-haul airplane and act out the process of refreshing themselves in the VR environment. The procedure follows:

1. Researchers welcome the participants.
2. Participants sign the consent form.
3. Researchers give an introduction and help participants recall their memories of their normal routine when they want to refresh themselves in airplane.
4. Participants fill in Pre-SSQ questionnaire.
5. Researchers lead participants to experiment area and run the experiment program.
6. Participants pretend to do their regular steps to refresh themselves in the VR environment.
7. Participants fill in Post-SSQ questionnaire, 7-scale design evaluation questionnaire, realistic questionnaire and presence questionnaire.

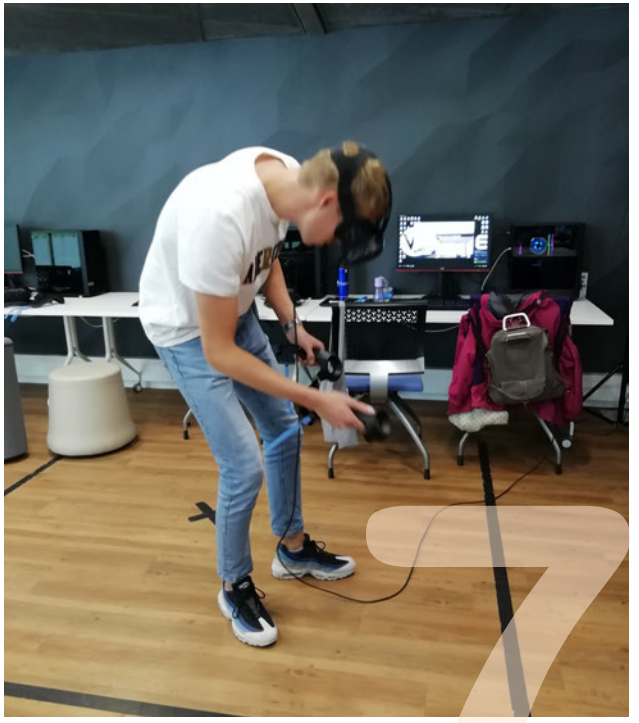


Figure 27 Example of a participant doing evaluation

The evaluation items are slightly different from the items used in the first VR experiment considering it is hard to evaluate single elements by doing a task involving multiple parts in the environment. The items used this time are decided base on different functions and activities may happen in the hygiene space- standing space, lighting effect, using water, using mirror, storage and hygiene facilities. The results are shown in figure 28. The general comfort got a score of 5.48 and scores for all the items are above 5 which means the final concept of the hygiene space can improve the comfort and satisfactory level as well as provide a better experience.

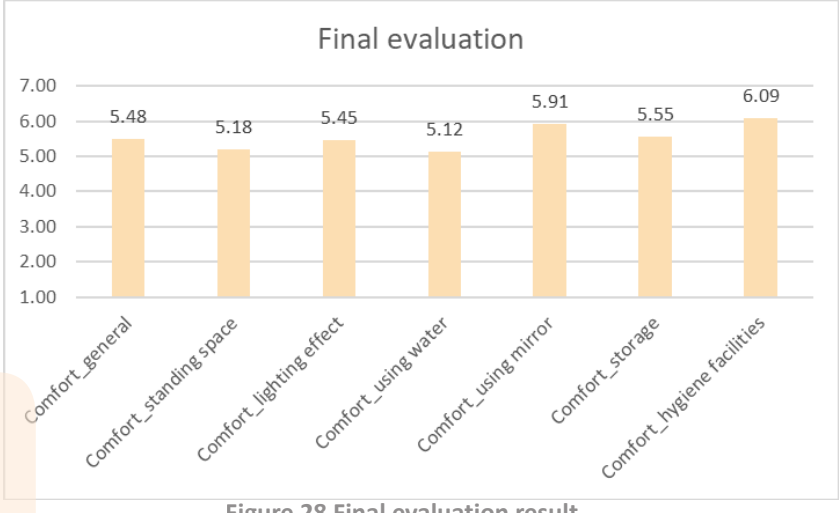


Figure 28 Final evaluation result

Benchmark

The most relevant benchmark for this project is the multipurpose room on ANA A380 which is already mentioned in previous chapters. This room is not typically aimed at refreshing and hygiene activities but also a place to have a place seperate from the crowd in the cabin. A sofa is provided and people can sit inside to have a “me time”. The rest of the setting is very similar to a normal toilet in any aircraft. People can clean themselves and have a refreshment but the experience of hygiene will not be too much different from a normal toilet. Baby care and changing clothes can also be done in this multipurpose room.

The newly designed concept is focusing on hygiene and refreshing activities. Two taps make it possible for two people to wash hands at the same time. The basin is large to collect splashing water and the height is reset so people do not need to bend too much. The distance between tap and basin is enlarged to enable a comfortable posture. Children can step on the stairs to reach tap easily. Different facilities are provided to create a convenient experience. It is not recommended to do baby care and clothes change in this place since in the new floor plan the changing room is provided and these activities can be done there. However, just a fordable board and a lock are needed to enable activities like baby care and clothes change.

Ch9.
Limitation and future suggestion

Constraints

There are many constraints in this project which may cause inaccuracy in the results. Firstly, all the experiments were done in the university, mostly with students. The diversity of participants was quite limited compared to real flight passengers. The age of participants was centred on 20-30 years old. The contribution from other age groups, especially children and elderly were missing. Secondly, the tool used in all the experiments were mainly VR headsets. Since the materials were not the main focus of this project, not much attention was paid on this. However, this can influence participants feeling of realism and immersion during the experiments. Also, in the VR environment, people can only see the headset in the mirror and controllers but no visibility on their body. The perception of the environment can be misleading due to the lack of reference of their body. It is not possible to touch the objects during the experiments. Although the space was separated by wood boards in the first experiment, the contribution to realism was very small.

Further opportunities

With the data of final evaluation, correlations between general comfort and different items were studied and correlations were found between 4 items and general comfort: standing space, using water, using mirror and storage. The significance is shown in table 10.

To avoid the errors caused by the unbalance of participants genders, correlations for the difference in genders were also studied and the results show that different genders can have a different focus when refreshing themselves. 19 males and 14 females are relatively small sample sizes and the results can be inaccurate, but the difference between different genders can be further studied to see whether it is necessary to design different functiona
genders.

Table 10 Correlations between score of general comfort and other items

	Standing space	Lighting effect	Using water	Using mirror	storage	Hygiene facilities
Sig.	0.005	0.068	0.003	0.044	0.001	0.739

Table 11 Correlations between score of general comfort and other items for different genders

	Standing space	Lighting effect	Using water	Using mirror	storage	Hygiene facilities
Sig.(male)	0.017	0.758	0.120	0.507	0.049	0.542
Sig.(female)	0.199	0.035	0.007	0.019	0.003	0.777

Ch10.
Reflection

This project was started with design the interior of Flying V and ended with the design of the area adjacent to the toilet, which is the hygiene space. Scientific experiments were performed during this process. The way to design experiments and methods to analyse different type of data were experienced and learned. Growth shows up on communication ability with different participants and control of the process. All the design decisions were made with a reasonable base.

However, there are still a lot can be improved. The file of the multipurpose room was found quite late in this process. It might be much more valuable and inspiring if detailed research has been done on this. The detailed design on the materials was not made because of the focus but this might reduce the realistic feeling of the envi t. If the process involved the pers ve o technical system, but not pur bout the rience of the activities, the de can be dif t and easy to be realized.

Th d result is resting as it is a concept ba on passe r experience, people's preference on warm light, need of storage for personal belongings and preferable distance between tap and bottom are important findings that could also be used in public space focusing on refreshing/ hygiene activities.

The scientific question difference between VR and desktop in the experiment are experienced quite clear that people performed much more sensitive to different height and light setting in VR than on desktop. Both test methods can cause slight discomfort during the experiments. The full potential of VR testing is too complex and further research are needed on this.

Ch11.
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Ch12.
Appendix

A. Online survey

A1. Online survey used in background study

Experience of Long-haul Flight over 8 Hours

This questionnaire is for the research elective on Flying V project in TU Delft. The main goal is to find out the desirable experience for future long-haul flight. The data will only be used in the following study. All materials will contain averages of the questionnaires and individuals will not be traceable.

1. **Gender**
   Mark only one oval.
   - ◯ Male
   - ◯ Female

2. **Age**
   Mark only one oval.
   - ◯ under 20
   - ◯ 20-30
   - ◯ 30-40
   - ◯ 40-50
   - ◯ 50-60
   - ◯ over 60

Part Ⅰ. about Your Past Experience

Please read the statements below and rank them from 1 to 7. 1 is totally not agree, 7 is totally agree and 4 is neutral.

3. **You feel bored although there is entertainment system.**
   Mark only one oval.

	1	2	3	4	5	6	7	
totally not agree	◯	◯	◯	◯	◯	◯	◯	totally agree

4. **Your mood gets better every time when food is served.**
   Mark only one oval.

	1	2	3	4	5	6	7	
totally not agree	◯	◯	◯	◯	◯	◯	◯	totally agree

5. **The kids in the airplane make you feel irritating.**
   Mark only one oval.

	1	2	3	4	5	6	7	
totally not agree	◯	◯	◯	◯	◯	◯	◯	totally agree

Full version: https://forms.gle/y3axehWoTrnCkeMC9

A2. Online survey used to define qualities

Satisfaction of Around-basin Activities

This questionnaire is for a graduation project in TU Delft. The main goal is to define different qualities of around-basin activities in flight and then apply to a new type of flight. The data will only be used in the following study. All materials will contain averages of the questionnaires and individuals will not be traceable.

1. **Gender**
   Mark only one oval.
   - ◯ Female
   - ◯ Male

Please rank the satisfaction of following situation . Remember, the context is in a long-haul flight and the flying time will be over 8 hours.

1=Very dissatisfied, 4=neutral, 7=Very satisfied

2. **If you have larger standing space around basin in flight, you feel**
   Mark only one oval.

	1	2	3	4	5	6	7	
Very dissatisfied	◯	◯	◯	◯	◯	◯	◯	Very satisfied

3. **If you have same standing space around basin as now, you feel**
   Mark only one oval.

	1	2	3	4	5	6	7	
Very dissatisfied	◯	◯	◯	◯	◯	◯	◯	Very satisfied

4. **If you can sit in front of the mirror, you feel**
   Mark only one oval.

	1	2	3	4			7	
Very dissatisfied	◯	◯	◯	◯	◯	◯	◯	Very sa

5. **If you can only stand in front of the mirror, you feel**
   Mark only one oval.

	1	2	3	4	5		7	
Very dissatisfied	◯	◯	◯	◯	◯	◯	◯	Very sat

Full version: https://forms.g p5rNPHP8jo 6

A2. Online survey used in interview

Hygiene space in airplane

This questionnaire is for a graduation project in TU Delft. The main goal is to find out the preference in hygiene space of a new type of flight. The data will only be used in the following study. All materials will contain averages of the questionnaires and individuals will not be traceable.

1. **Which color temperature do you prefer for hygiene space?**

Mark only one oval.

- 3800K
- 3500K
- 3200
- 300
- 27
- 2
- 2

Full ve https:https ms.gle/MzKK8H1czwQQ2Pr4A

B. Experiment materials

Participant number: Time:

Pre-exposure Simulator Sickness Questionnaire

SYMPTOM CHECKLIST (Pre-exposure)

Pre-exposure instructions: please fill in this questionnaire. Circle below if any of the symptoms apply to you now. You will be asked to fill this again after the experiment.

一般不适	1. General discomfort	None	Slight	Moderate	Severe
疲 倦	2. Fatigue	None	Slight	Moderate	Severe
头 痛	3. Headache	None	Slight	Moderate	Severe
眼 痛	4. Eyestrain	None	Slight	Moderate	Severe
很难集中視力	5. Difficulty focusing	None	Slight	Moderate	Severe
口水分泌增加	6. Salivation increase	None	Slight	Moderate	Severe
出 汗	7. Sweating	None	Slight	Moderate	Severe
作 呕	8. Nausea	None	Slight	Moderate	Severe
很难集中精神	9. Difficulty concentrating	None	Slight	Moderate	Severe
头胀	10. "Fullness of the head"	No	Yes (Slight	Moderate	Severe)
視野模糊	11. Blurred vision	No	Yes (Slight	Moderate	Severe)
眼 花 (开)	12. Dizziness eyes open	No	Yes (Slight	Moderate	Severe)
眼 花 (合)	13. Dizziness eyes close	No	Yes (Slight	Moderate	Severe)
眩晕*	14. *Vertigo	No	Yes (Slight	Moderate	Severe)
胃感觉异样**	15. **Stomach awareness	No	Yes (Slight	Moderate	Severe)
打 嗝	16. Burping	No	Yes (Slight	Moderate	Severe)

* Vertigo is experienced as loss of orientation with respect to vertical upright.

** Stomach awareness is usually used to indicate a feeling of discomfort which is just short of nausea.

Version-A Type

Participant number Time

Gender Age

1. Please give your score base on the condition with seat.

1	2	3	4	5	6	7

2. Please give your score base on the condition no seat.

1	2	3	4	5	6	7

3. Please give your score base on current light condition (3000k).

1	2	3	4	5	6	7

4. Please give your score base on current light condition (3500k).

1	2	3	4	5	6	7

5. Please give your score base on current basin height (24cm).

1	2	3	4	5	6	7

6. Please give your score base on current basin height (28cm).

1	2	3	4	5	6	7

7. Please give your score base on current storage condition (1).

1	2	3	4	5	6	7

8. Please give your score base on current storage condition (2).

1	2	3	4	5	6	7

9. Please give your score base on current facilities including hand soap and hand cream.

1	2	3	4	5	6	7

10. Please give your score base on current facilities including hand soap, hand cream, cleaning wipes, cotton swabs, cotton pads, comb and hair drier.

1	2	3	4	5	6	7

Comments & suggestions

Post-exposure Simulator Sickness Questionnaire

SYMPTOM CHECKLIST (Post-exposure)

Post-exposure instruction: please fill in this questionnaire once more. Circle below if any of the symptoms apply to you now.

一般不适	1. General discomfort	None	Slight	Moderate	Severe
疲 倦	2. Fatigue	None	Slight	Moderate	Severe
头 痛	3. Headache	None	Slight	Moderate	Severe
眼 痛	4. Eyestrain	None	Slight	Moderate	Severe
很难集中視力	5. Difficulty focusing	None	Slight	Moderate	Severe
口水分泌增加	6. Salivation increase	None	Slight	Moderate	Severe
出 汗	7. Sweating	None	Slight	Moderate	Severe
作 呕	8. Nausea	None	Slight	Moderate	Severe
很难集中精神	9. Difficulty concentrating	None	Slight	Moderate	Severe
头胀	10. "Fullness of the head"	No	Yes (Slight	Moderate	Severe)
視野模糊	11. Blurred vision	No	Yes (Slight	Moderate	Severe)
眼 花 (开)	12. Dizziness eyes open	No	Yes (Slight	Moderate	Severe)
眼 花 (合)	13. Dizziness eyes close	No	Yes (Slight	Moderate	Severe)
眩晕*	14. *Vertigo	No	Yes (Slight	Moderate	Severe)
胃感觉异样**	15. **Stomach awareness	No	Yes (Slight	Moderate	Severe)
打 嗝	16. Burping	No	Yes (Slight	Moderate	Severe)

* Vertigo is experienced as loss of orientation with respect to vertical upright.

** Stomach awareness is usually used to indicate a feeling of discomfort which is just short of nausea.

C. Evaluation materials

Participant number: Time:

Pre-exposure Simulator Sickness Questionnaire
SYMPTOM CHECKLIST (Pre-exposure)

Pre-exposure instructions: please fill in this questionnaire. Circle below if any of the symptom apply to you now. You will be asked to fill this again after the experiment.

一般不适	1. General discomfort	None	Slight	Moderate	Severe
疲 倦	2. Fatigue	None	Slight	Moderate	Severe
头 痛	3. Headache	None	Slight	Moderate	Severe
眼 痛	4. Eyestrain	None	Slight	Moderate	Severe
很难集中视力	5. Difficulty focusing	None	Slight	Moderate	Severe
口水分泌增加	6. Salivation increase	None	Slight	Moderate	Severe
出 汗	7. Sweating	None	Slight	Moderate	Severe
作 呕	8. Nausea	None	Slight	Moderate	Severe
很难集中精神	9. Difficulty concentrating	None	Slight	Moderate	Severe
头胀	10. "Fullness of the head"	No	Yes (Slight	Moderate	Severe)
视野模糊	11. Blurred vision	No	Yes (Slight	Moderate	Severe)
眼 花 (开)	12. Dizziness eyes open	No	Yes (Slight	Moderate	Severe)
眼 花 (合)	13. Dizziness eyes close	No	Yes (Slight	Moderate	Severe)
眩晕*	14. *Vertigo	No	Yes (Slight	Moderate	Severe)
胃感觉异样**	15. **Stomach awareness	No	Yes (Slight	Moderate	Severe)
打 嗝	16. Burping	No	Yes (Slight	Moderate	Severe)

* Vertigo is experienced as loss of orientation with respect to vertical upright.

** Stomach awareness is usually used to indicate a feeling of discomfort which is just short of nausea.

Post-exposure Simulator Sickness Questionnaire
SYMPTOM CHECKLIST (Post-exposure)

Post-exposure instruction: please fill in this questionnaire once more. Circle below if any of the symptoms apply to you now.

一般不适	1. General discomfort	None	Slight	Moderate	Severe
疲 倦	2. Fatigue	None	Slight	Moderate	Severe
头 痛	3. Headache	None	Slight	Moderate	Severe
眼 痛	4. Eyestrain	None	Slight	Moderate	Severe
很难集中视力	5. Difficulty focusing	None	Slight	Moderate	Severe
口水分泌增加	6. Salivation increase	None	Slight	Moderate	Severe
出 汗	7. Sweating	None	Slight	Moderate	Severe
作 呕	8. Nausea	None	Slight	Moderate	Severe
很难集中精神	9. Difficulty concentrating	None	Slight	Moderate	Severe
头胀	10. "Fullness of the head"	No	Yes (Slight	Moderate	Severe)
视野模糊	11. Blurred vision	No	Yes (Slight	Moderate	Severe)
眼 花 (开)	12. Dizziness eyes open	No	Yes (Slight	Moderate	Severe)
眼 花 (合)	13. Dizziness eyes close	No	Yes (Slight	Moderate	Severe)
眩晕*	14. *Vertigo	No	Yes (Slight	Moderate	Severe)
胃感觉异样**	15. **Stomach awareness	No	Yes (Slight	Moderate	Severe)
打 嗝	16. Burping	No	Yes (Slight	Moderate	Severe)

* Vertigo is experienced as loss of orientation with respect to vertical upright.

** Stomach awareness is usually used to indicate a feeling of discomfort which is just short of nausea.

Basic Information
Gender: M / F Age:

Experience on VR: None / AR app / VR cardboard / High-end VR headset

Concept evaluation
Please rate the comfort and satisfactory level of different components in the envirionment, by circling your score in the box.

1. Please give your score on the general condition.

Dissatisfied/Uncomfortable						Very satisfied/comfortable
1	2	3	4	5	6	7

2. Please give your score based on the condition: Standing space

Dissatisfied/Uncomfortable						Very satisfied/comfortable
1	2	3	4	5	6	7

3. Please give your score based on the condition: Lighting effect

Dissatisfied/Uncomfortable						Very satisfied/comfortable
1	2	3	4	5	6	7

4. Please give your score based on the condition: Using water

Dissatisfied/Uncomfortable						Very satisfied/comfortable
1	2	3	4	5	6	7

5. Please give your score based on the condition:

Dissatisfied/Uncomfortable						Very satisfied/comfortable
1	2	3	4	5	6	7

6. Please give your score based on the condition: Storage

Dissatisfied/Uncomfortable						Very satisfied/comfortable
1	2	3	4	5	6	7

7. Please give your score based on the condition: Hygiene facilities

Dissatisfied/Uncomfortable						Very satisfied/comfortable
1	2	3	4	5	6	7

Your comment and suggestions:

Realistic Level
Please rate that how realstic your exprience in the envirionment, by circling your score in the box.

8. Please give your score based on the condition: Standing space

Not Realistic						Very Realistic
1	2	3	4	5	6	7

9. Please give your score based on the condition: Lighting effect

Not Realistic						Very Realistic
1	2	3	4	5	6	7

10. Please give your score based on the condition: Using water

Not Realistic						Very Realistic
1	2	3	4	5	6	7

11. Please give your score based on the condition:

Not Realistic						Very Realistic
1	2	3	4	5	6	7

12. Please give your score based on the condition: Storage

Not Realistic						Very Realistic
1	2	3	4	5	6	7

13. Please give your score based on the condition: Hygiene facilities

Not Realistic						Very Realistic
1	2	3	4	5	6	7

Your comment and suggestions:

PRESENCE QUESTIONNAIRE

(Witmer & Singer, Vs. 3.0, Nov. 1994)*
Revised by the UQO Cyberpsychology Lab (2004)

Characterize your experience in the environment, by marking an "X" in the appropriate box of the 7-point scale, in accordance with the question content and descriptive labels. Please consider the entire scale when making your responses, as the intermediate levels may apply. Answer the questions independently in the order that they appear. Do not skip questions or return to a previous question to change your answer.

WITH REGARD TO THE EXPERIENCED ENVIRONMENT

1. How much were you able to control events?

NOT AT ALL			SOMEWHAT			COMPLETELY

2. How responsive was the environment to actions that you initiated (or performed)?

NOT RESPONSIVE			MODERATELY RESPONSIVE			COMPLETELY RESPONSIVE

3. How natural did your interactions with the environment seem?

EXTREMELY ARTIFICIAL			BORDERLINE			COMPLETELY NATURAL

4. How much did the visual aspects of the environment involve you?

NOT AT ALL			SOMEWHAT			COMPLETELY

5. How natural was the mechanism which controlled movement through the environment?

EXTREMELY ARTIFICIAL			BORDERLINE			COMPLETELY NATURAL

6. How compelling was your sense of objects moving through space?

NOT AT ALL			MODERATELY COMPELLING			VERY COMPELLING

7. How much did your experiences in the virtual environment seem consistent with your real world experiences?

NOT CONSISTENT			MODERATELY CONSISTENT			VERY CONSISTENT

8. Were you able to anticipate what would happen next in response to the actions that you performed?

NOT AT ALL			SOMEWHAT			COMPLETELY

9. How completely were you able to actively survey or search the environment using vision?

NOT AT ALL			SOMEWHAT			COMPLETELY

10. How compelling was your sense of moving around inside the virtual environment?

NOT COMPELLING			MODERATELY COMPELLING			VERY COMPELLING

11. How closely were you able to examine objects?

NOT AT ALL			PRETTY CLOSELY			VERY CLOSELY

12. How well could you examine objects from multiple viewpoints?

NOT AT ALL			SOMEWHAT			EXTENSIVELY

13. How involved were you in the virtual environment experience?

NOT INVOLVED			MILDLY INVOLVED			COMPLETELY ENGROSSED

14. How much delay did you experience between your actions and expected outcomes?

NO DELAYS			MODERATE DELAYS			LONG DELAYS

15. How quickly did you adjust to the virtual environment experience?

NOT AT ALL			SLOWLY			LESS THAN ONE MINUTE

16. How proficient in moving and interacting with the virtual environment did you feel at the end of the experience?

NOT PROFICIENT			REASONABLY PROFICIENT			VERY PROFICIENT

17. How much did the visual display quality interfere or distract you from performing assigned tasks or required activities?

NOT AT ALL			INTERFERED SOMEWHAT			PREVENTED TASK PERFORMANCE

18. How much did the control devices interfere with the performance of assigned tasks or with other activities?

NOT AT ALL			INTERFERED SOMEWHAT			INTERFERED GREATLY

19. How well could you concentrate on the assigned tasks or required activities rather than on the mechanisms used to perform those tasks or activities?

NOT AT ALL			SOMEWHAT			COMPLETELY