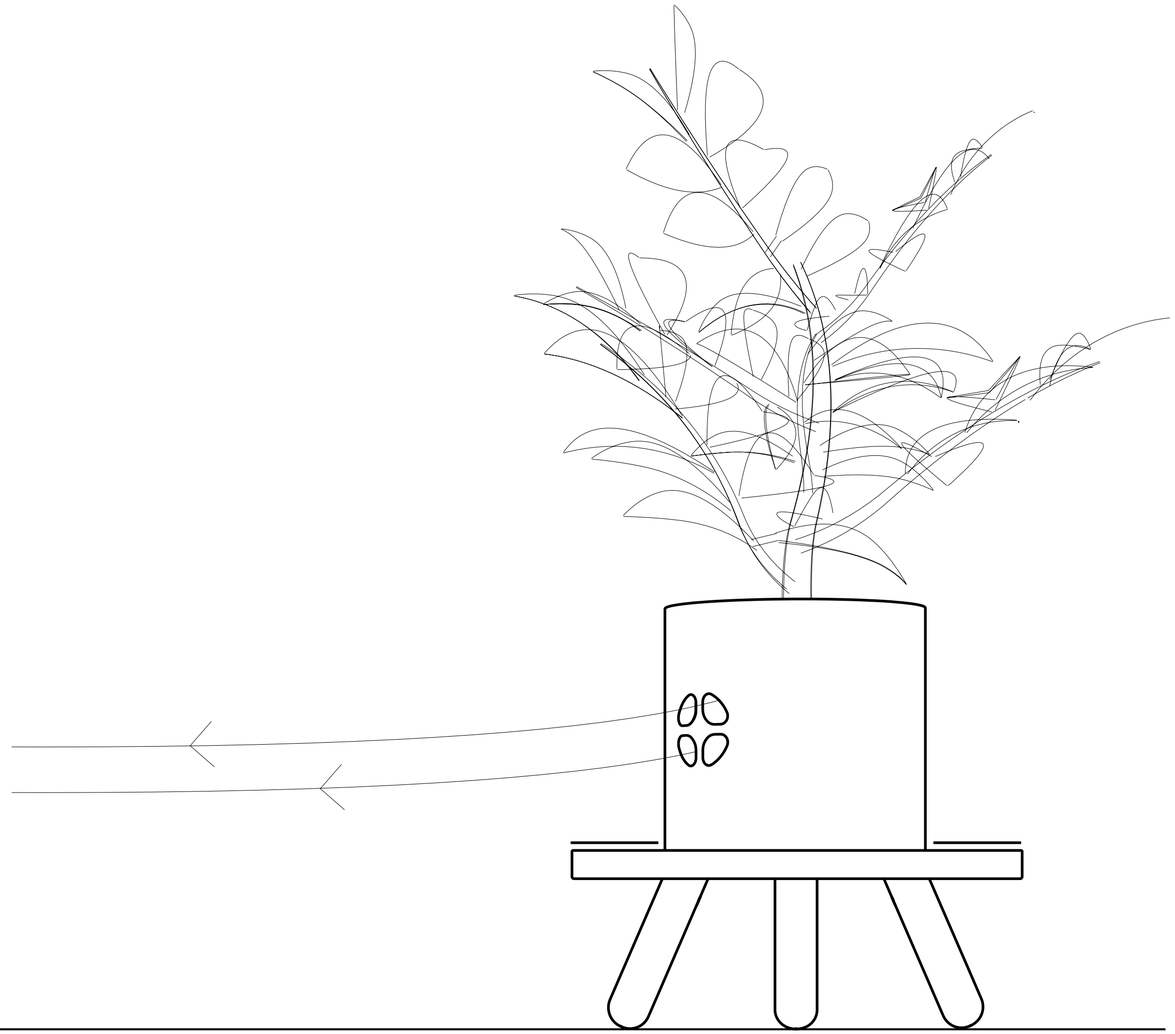
Design of a
nature-based air
purifier

/ Appendices



Master Thesis of
Antonio Chozas Plasencia

Delft University of Technology
Industrial Design Engineering
December, 2020

/ Appendix 1: Project brief

Personal Project Brief - IDE Master Graduation

TU Delft

TO2em: Development of a nature-based air purifier — project title

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

start date 07 - 05 - 2020 — 03 - 11 - 2020 end date

INTRODUCTION **

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

Indoor air quality
People spend most of the time at interior spaces, such as houses, factories or offices. These are isolated spaces, that protect people from the temperature outside and the weather calamities. At the same time, the isolation in these spaces implies that the human being is taken away from its natural environment, and brought to enclosed spaces where the air quality is not optimal. Synthetic materials like varnishes, inks, paints plastics, cleaning products, printers, or even other human being are considered a source of indoor air pollution as they emit various organic compounds which have been linked to different health complaints. Without a proper ventilation, these enclosed environments can cause headaches, drowsiness, irritation in eyes, nose, throat and skin or psychological disturbances.

Stakeholders
Stating indoor air pollution as the problem to address, two main stakeholders can be found. First one, the individual who develops its life inside buildings. This can be an employee that works in an office. He is concerned about his health, and he can take small actions like opening windows for ventilation, placing plants or bringing an air purifier.
The second stakeholder would be the owner/responsible of the building. This can be a boss of a company. He is concerned about the health of his employees, and he can take part with bigger actions such as equipping the building with a proper ventilation/filtration system.

Technology
Nowadays, there are diverse options when it comes to improve the indoor air quality. The range goes from simple natural solutions, such as providing the space of plants that are well known from their purification capacity (golden pothos, English evy, etc ...); to sophisticated electronic devices that circulate the air through mechanic filters.
The solution proposed for this project, could be seen as the meeting ground between the two previous options. It is a nature-based solution, which optimizes the purification capacity of the plants by circulating air through its roots, using a patented air circulation system.
How developed is the technology behind the proposed solution? The technology principle has been already tested and proved. This was achieved with a previous version -MUAC, Modules for Urban Air Cleaning (picture 1)- designed for a different context, air purification in the cities (first picture). Besides, similar solutions for indoor purification can be found already in the market (picture 2).

Opportunities and limitations
Given the mentioned context and stakeholders, first there is an opportunity in the market to place a product that can be used by people to improve the air quality of their indoor working/living spaces. Technologicwise, there is an opportunity of developing a product that is cheaper, more sustainable (less electric consumption) and has a completely different user experience than electronic air purifiers; and on the other hand, is more efficient when compared with the use of plants.
Regarding to limitations, the technology itself is limited by the purification capacity of a plant, and it's performance is directly dependent on the maintenance that the plant is receiving, making it a very dependent technology. Looking into the society, the awareness of the effects of indoor air pollution and the grade of importance that is given to this problem, will probably limit the amount of money people is willing to spend for such a solution.

space available for images / figures on next page

Personal Project Brief - IDE Master Graduation

TU Delft

introduction (continued): space for images

image / figure 1: MUAC: Modules for Urban Air Cleaning

image / figure 2: Some nature-based indoor purifiers that can be found in the current market

PROBLEM DEFINITION **

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

The indoor air quality is a problem in our current society, affecting to the health of the people which is spending a big amount of hours of the day at interior spaces. Next to this problem, a recent technology that combines plants with air circulation seems to be promising to be effective in purifying the indoor air. In addition, being electronic-mechanic filters the main solution in the market, this technology enables the development of a very different alternative solution, more sustainable and natural.

Given these conditioning factors, the situation is now ready for a design process, that will have as main purpose answering the following questions:

How to translate the technology developed with MUAC into an indoor air purifier?
How to make it appealing for the user?
How to integrate both areas, user and technology?

ASSIGNMENT **

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

The aim is to develop an indoor air purifier that integrates the MUAC technology with a deep understanding of the user needs, emotions and desires.

At the end of the graduation project, I expect to have a final product design, that meets the following requirements:

/ Optimal use of the technology
/ Product interaction designed for an specific target group
/ Product aesthetics designed for an specific target group

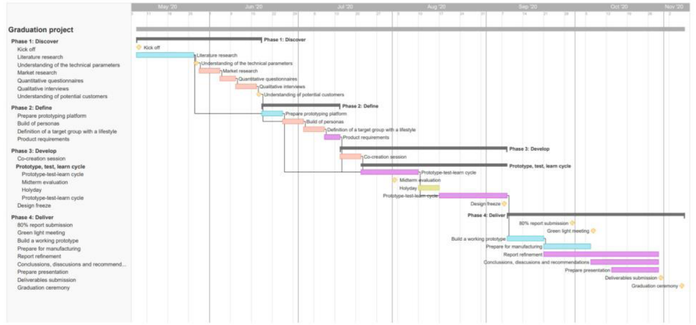
In addition, I expect to have a report that meets the following points:

/ Explanatory scheme about how playing with the different technical parameters can variate the performance. To be used as a guide in future upgrades
/ Manufacturing process, and producing cost of the unity. To be used as an input in the business model

PLANNING AND APPROACH **

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

start date 7 - 5 - 2020 3 - 11 - 2020 end date



Phase 1: Discover
As a first step, have a deep understanding of the technology behind the product. This is, understand how the different parameters (geometry, contact area, fan speed ...) can affect the purifying performance. Next to it, a literature research on the available methodologies to test the performance of an air purifier.
With the technical possibilities clear, the second step would be to understand the potential consumers, and get insights from them.
Phase 2: Define
In the first place, define and prepare an adaptable prototyping platform where the technical performance of the design can be tested.
With all the data and insights obtained in the previous phase, define a clear picture of how the "target group with a specific lifestyle" is, thinks, and what are their desires, taste, aspirations, etc... Finally, understanding the technical possibilities and the user, define the product requirements.
Phase 3: Develop
To start the ideation, organize a co-creation session with potential users, to let them design their desired purifier. Subsequently, start the design phase with a constant contact with the user, by going around a continuous cycle of prototype-test-learn. The midterm evaluation will decide whether the designing phase is on a good track. Coming back from holiday, with a different perspective, I will have time to conclude the design before the design freeze.
Phase 4: Deliver
Build a working prototype, prepare this final design for manufacturing and come up with different alternatives and costs. Next to this, collect all the obtained results and prepare them to be shared.

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MOTIVATION AND PERSONAL AMBITIONS

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

First of all, I set up this project because I believe in the philosophy behind it: increasing the quality of life by reconnecting the human to the nature, and empowering him to be participant of the natural processes.

Reflecting about what do I want to learn during this graduation period, I found that there are still some skills that I want to learn, and others that I want to consolidate. These are my learning goals:

/ A. Be able to go through the whole design process alone. Usually, when working with teams, I end up focusing in the areas that I enjoy the most like prototyping, managing or creative sessions. At the same time, I usually avoid reporting, taking care of the organization, acquiring knowledge from experts, 'boring' previous research...
Now it's a great opportunity to experience the whole design process alone, so I can see myself in every state, and get the confidence of knowing that I know the whole process. I think this skill can be very relevant in the future I plan to manage a project.

/ B. Be able to work in an organized way. Usually, I have a mess in the folders where I save the work, which can lead me to extra time in searching for something, repeating some work already done, missing things (references, inspiration, ...) that I didn't save properly and not being able to share effectively with others partners.
Now it's time to spend some time in arranging a good set up at the beginning, so then it's easy and fast to save, search and share documents.

/ C. Use and learn the 3d modelling software Fusion360. This learning goal is related to the previous one, which is working in a more organized way. I used this software during a recent internship, and I realised that can lead to a better organized work. Besides, is very convenient for long term projects, as it makes it easy to fix parameters and adjust the different parts. During this internship I didn't have enough time to learn it completely, and I would like to take this opportunity to work from the beginning with the software and get used to it.

/ D. Build the design around constant user testing. Usually, I end up listening more to myself, and assume facts, instead of checking with other people. I have appreciated in other projects how useful is to have the constant feedback of users, and integrate this feedback in the process so the design is built around it. I think it's an useful methodology that should be the base of the majority of design projects.
Given the nature of my project, I believe that it's a good opportunity to implement this methodology and learn how to do it effectively.

FINAL COMMENTS

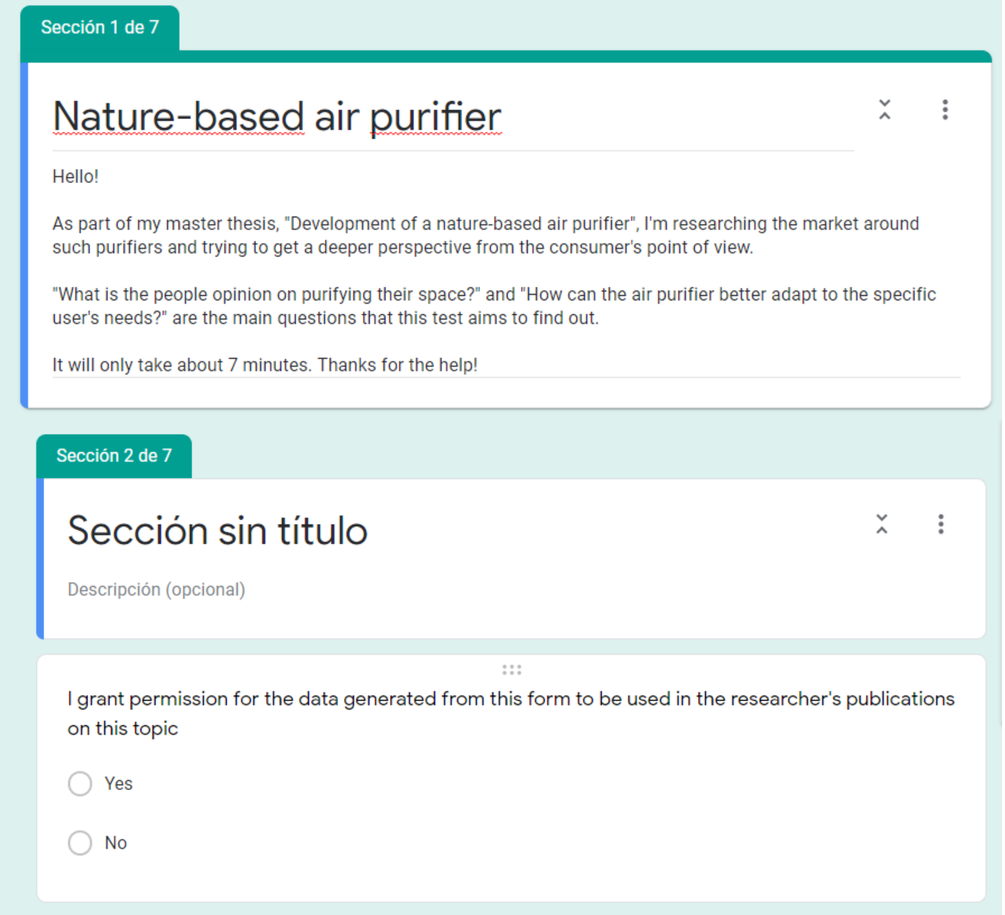
In case your project brief needs final comments, please add any information you think is relevant.

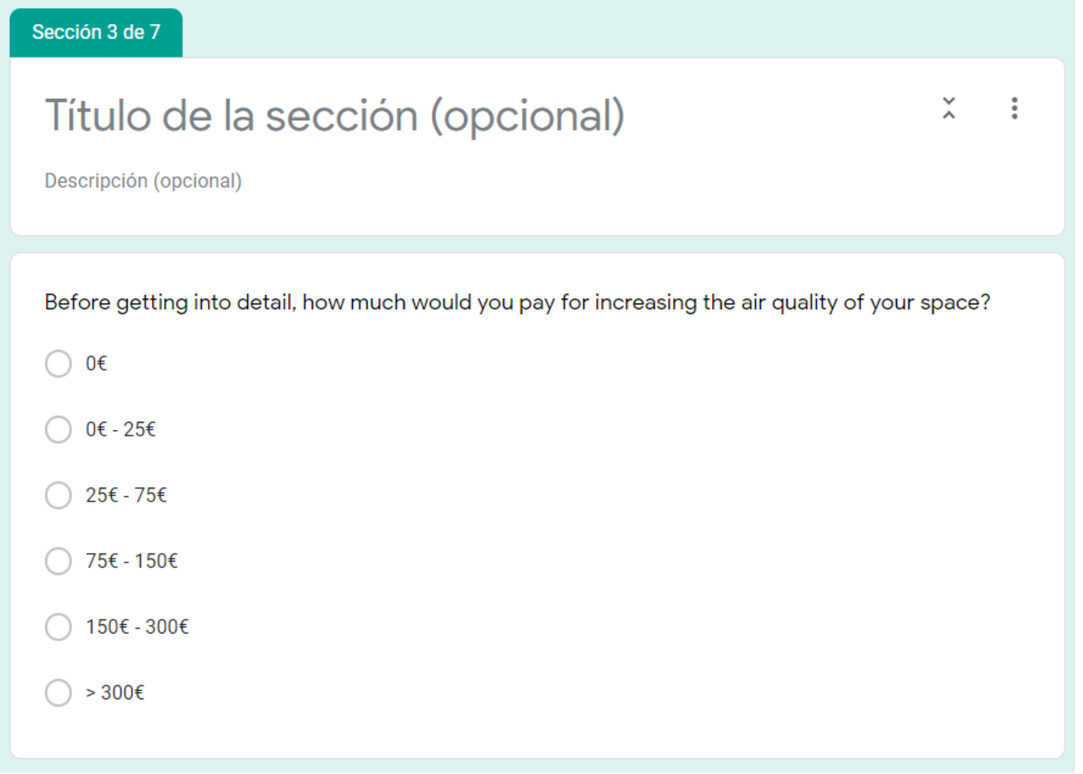
To be able to combine the graduation project with a side job (1 day per week), I'm planning the gradution to take place in 100 days distributed in 25 weeks, being 4 days per week.

Initials & Name A Chozas Plasencia Student number 4711548

Title of Project TO2em: Development of a nature-based air purifier

/ Appendix 2: Target group questionnaire





Sección 4 de 7

Introduction

Why is it important to purify the indoor air?

- Most of the people spend 90% of their time at indoor spaces.

- A large amount of household products (furniture, paints, varnishes, cleaning products, etc...) constantly discharge pollutants during its lifetime. Indoor air level pollutants may be 5 times higher than outdoor level.

- This accumulation of contaminants can lead to short term effects in the human's health such as the Sick Building Syndrome (headache, dizziness, fatigue, eye-nose-throat irritation...) as well as long term effects like respiratory diseases or different types of cancer.

Sección 5 de 7

Nature-based air purifier

What is a nature-based air purifier? Very simple. It is a device that optimizes the plants capacity to purify the air. To give you an idea of how it looks like, the following image displays different purifiers that can be found in the market

Título de la imagen

Sección 6 de 7

Customize your air purifier

In this section, I would like you to think of the air purifier you would like to find in a shop, and decide the main features you would like it to have.

Depending on the price you are willing to accept, you may need to restrict some of the features. If you are not happy with the price, you can always go back and change your selections.

Where do you think you will use the purifier?

- Office/Place where I work
- In the place where I work at home
- In my room
- In my living room
- I my kitchen
- Otra...

Product's size

- Small - 30€

- Medium - 50€

- Large - 70€

Where would you place the purifier?

- On the desk where I work
- On a desk where I don't work
- On a chair
- On the floor
- Otra...

Air purification technology

- Basic: Increases the purifying capacity of a regular plant by 6 times
- Medium: Increases the purifying capacity of a regular plant by 30 times (+20€)
- Advanced: Increases the purifying capacity of a regular plant by 60 times, and due to a complementary filt...

Watering system

- Water it like a standard potted plant
- Water tank, so I can water each 3 weeks (+10€)
- Water tank + water level indicator that shows when the plant needs water (+15€)

Powering system

- Plugged by a cord
- Batteries that I have to change twice per year (+5€)
- USB chargeable battery, that I have to charge once pero month (+10€)
- Solar powered system (+20€)

Sensors connected to an app in your smartphone

- ○ No sensors, no app
- ○ No app, but the device displays the T (temperature) and %H (relative humidity) of the room (+10€)
- ○ Detects when the plant needs water + T and %H shown in the app (+40€)
- ○ Air quality levels monitored in the app + Detects when the plant needs water + T and %H shown in the app ...

Now I would like to ask you to calculate the total amount that your purifier will cost. If you are not happy with the price you can always change the selected options

Texto de respuesta corta

How interested would you be in getting such a product?

	1	2	3	4	5	6	7	
Not interested at all	○	○	○	○	○	○	○	Very interested

Is there anything that yo will change in your resulting device? (Price, different features, other suggestions...)

Texto de respuesta larga

Sección 7 de 7

User details

This is the last section. Here, I would like to know a bit more about yourself. If you don't feel comfortable with answering a question, you can select 'I don't want to answer'

Age

- ○ <25
- ○ 25-35
- ○ 35-50
- ○ 50-65
- ○ >65
- ○ I don't want to answer

Gender

- Male
- Female
- Other
- I don't want to answer

Nationality

Texto de respuesta corta

Where do you live?

- Metropolis (> 1.000.000)
- Large city (300.000 to 1.000.000)
- City (100.000 to 300.000)
- Town (20.000 to 100.000)
- Village (< 20.000)
- I don't want to answer

Which is the higher degree of studies you have been participating?

- School
- High School
- Bachelor
- Master
- PhD
- I don't want to answer
- Otra...

For how long have you been working in your current profession?

- < 1 year
- Between 1 and 3 years
- Between 3 and 10 years
- > 10 years
- I'm retired
- I'm not working currently
- I don't want to answer

What type of household do you live in?

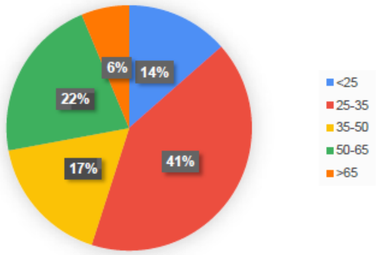
- I live in my parent's house
- I live alone
- I live with my partner
- I live with friends
- I live with my kids
- I don't want to answer
- Otra...

/ Appendix 3: Target group questionnaire's results

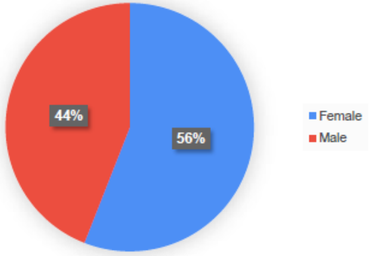
General results: demographic & socioeconomic data

/ 111 people surveyed

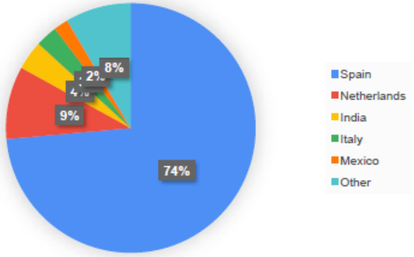
Age



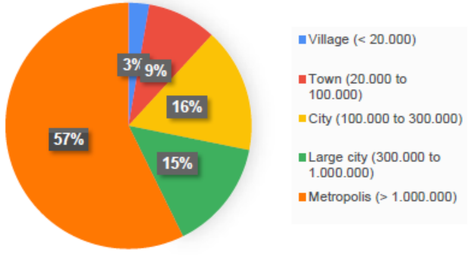
Gender



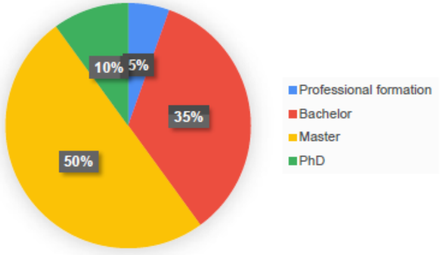
Nationality



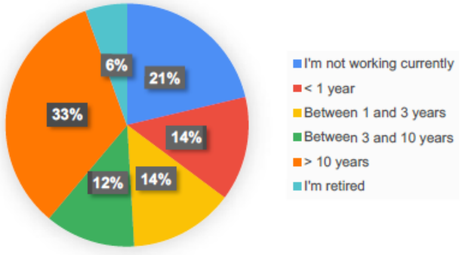
Where do you live?



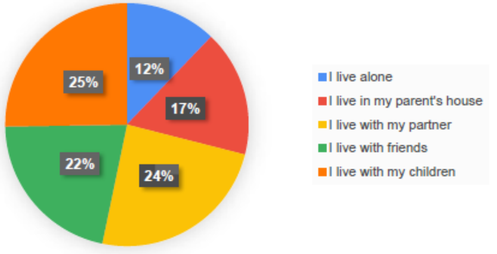
Which is the higher degree of studies you have been participating?



For how long have you been working in your current profession?

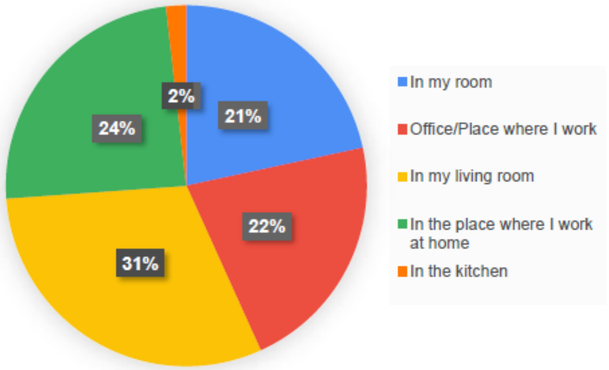


What type of household do you live in?

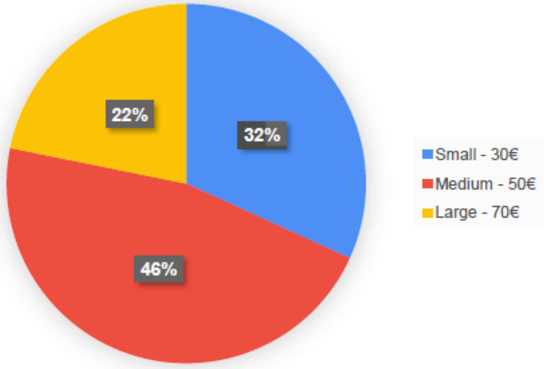


General results: size & location

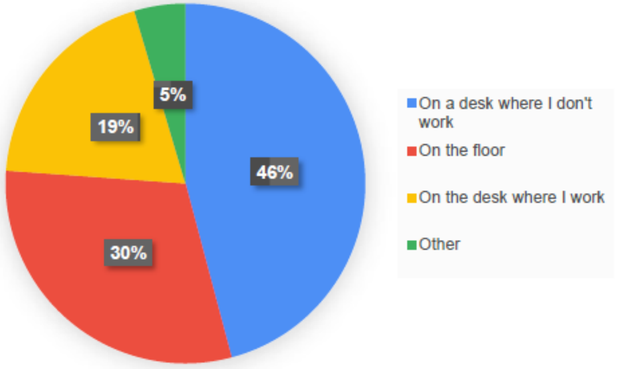
Where do you think you will use the purifier?



Product's size

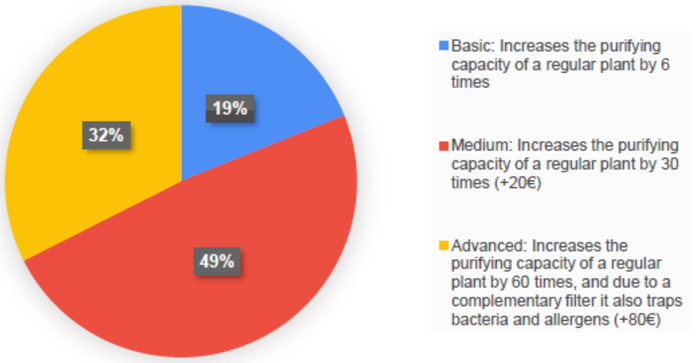


Where would you place the purifier?

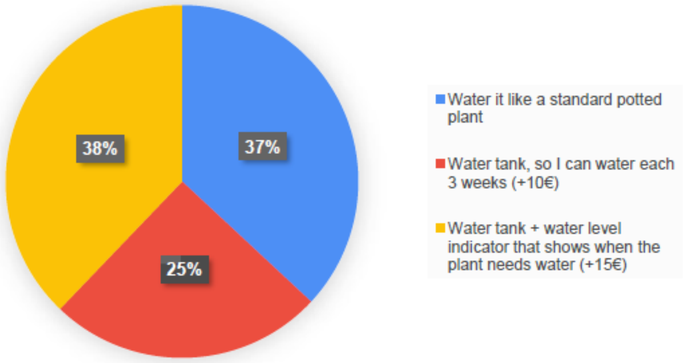


General results: desired features

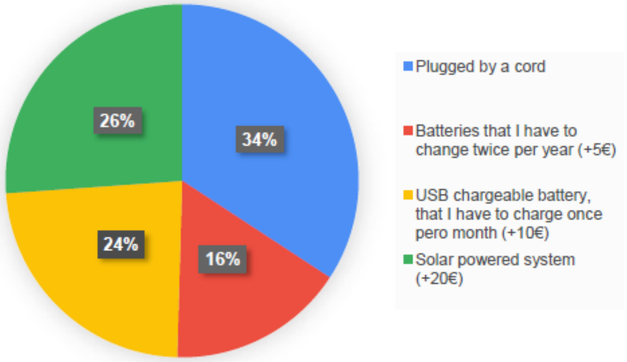
Air purification technology



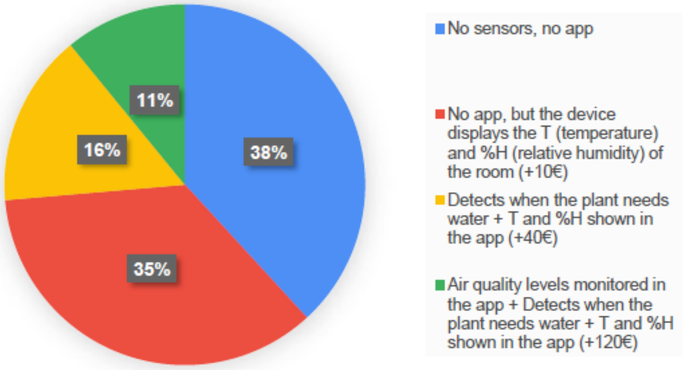
Watering system



Powering system

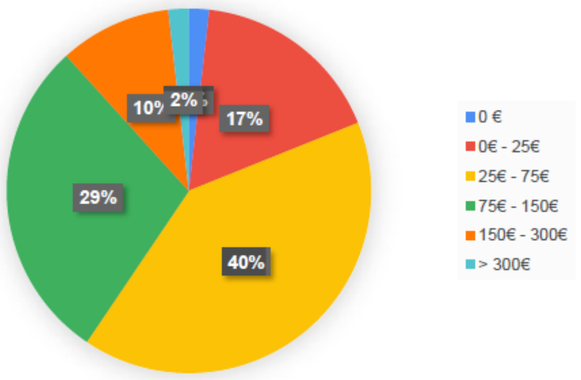


Sensors connected to an app in your smartphone

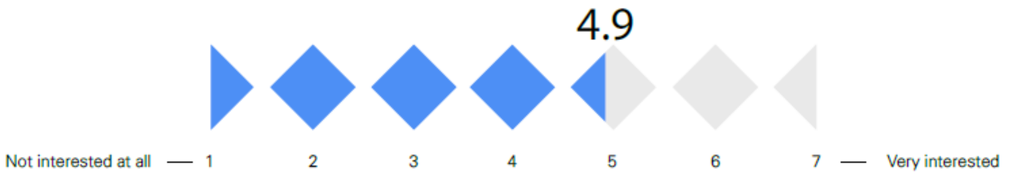


General results: price & interest

Before getting into detail, how much would you pay for increasing the air quality of your space?



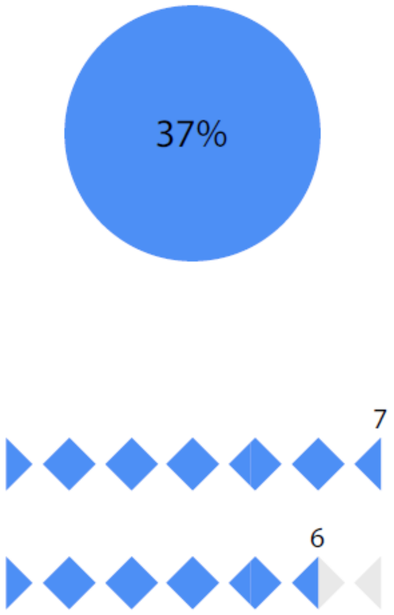
Average grade of interest in the customized purifier



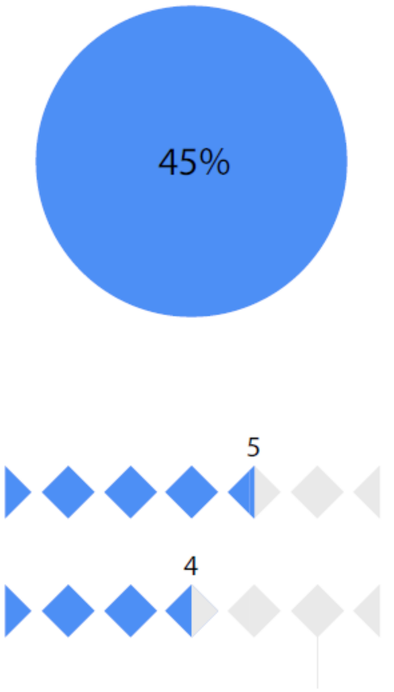
Average price of the customized purifier

Who is interested, who is indifferent and who is disinterested?

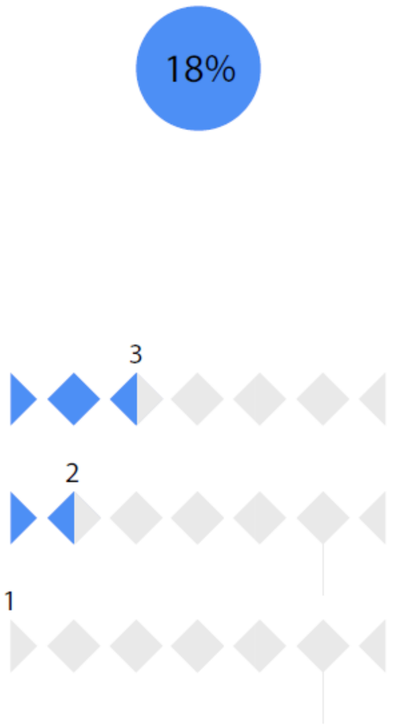
Group I: Interested people



Group II: Indifferent people

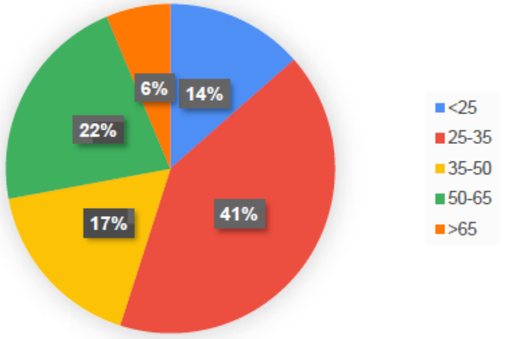


Group III: Disinterested people

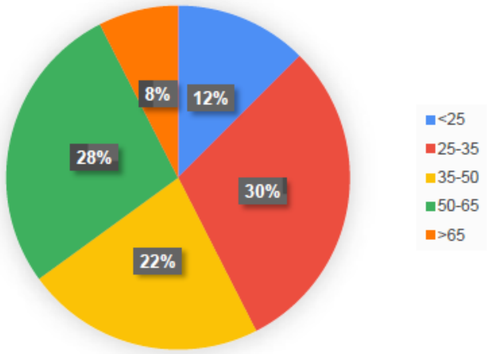


Who is interested, who is indifferent and who is disinterested? Age

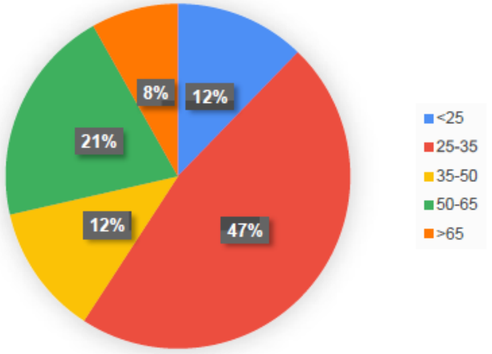
General results



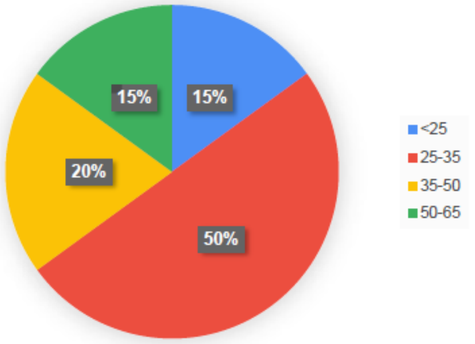
Group I: Interested people



Group II: Indifferent people



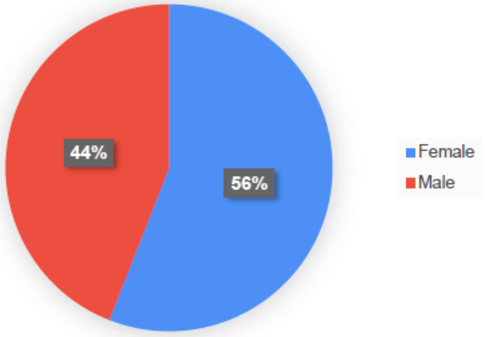
Group III: Disinterested people



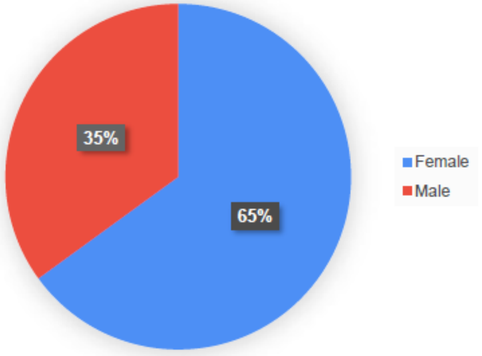
Who is interested, who is indifferent and who is disinterested?

Gender

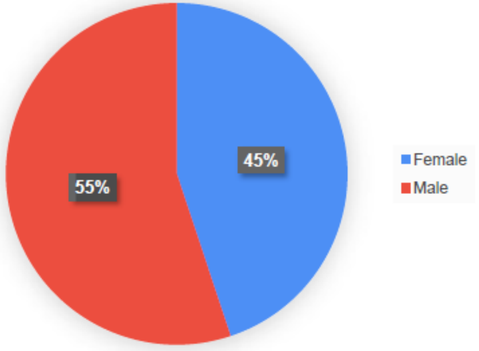
General results



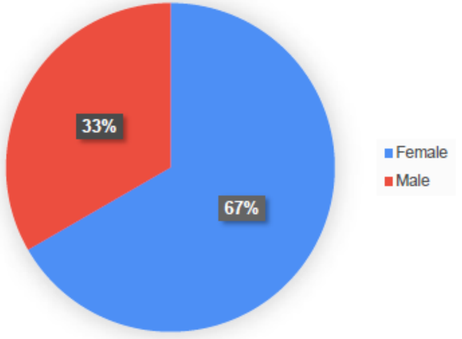
Group I: Interested people



Group II: Indifferent people



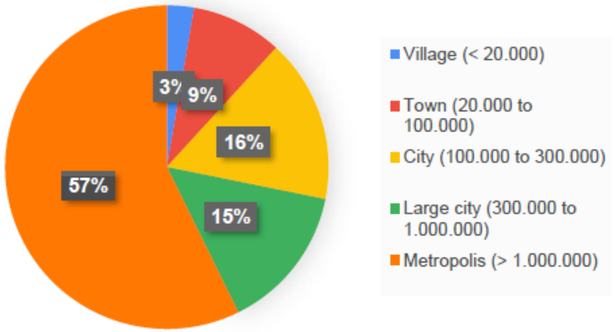
Group III: Disinterested people



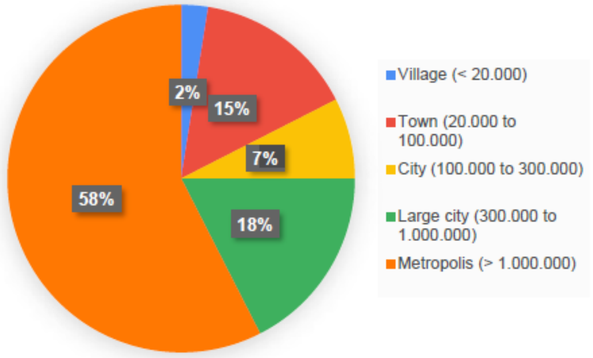
Who is interested, who is indifferent and who is disinterested?

City's size

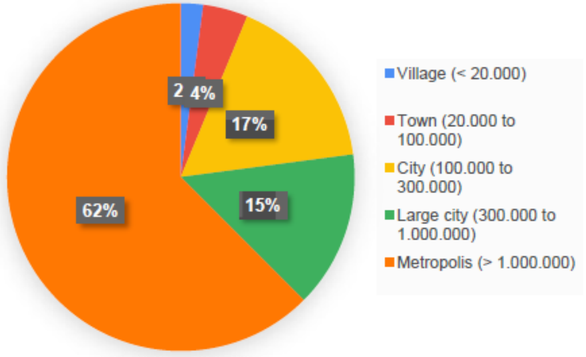
General results



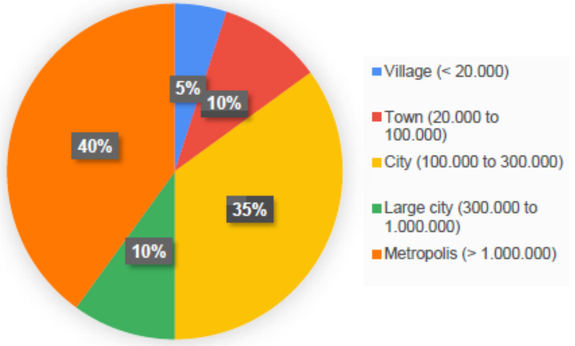
Group I: Interested people



Group II: Indifferent people



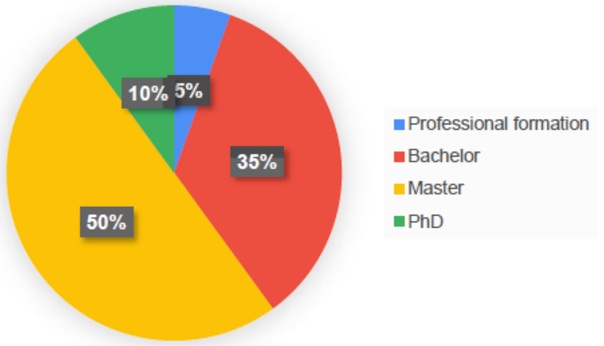
Group III: Disinterested people



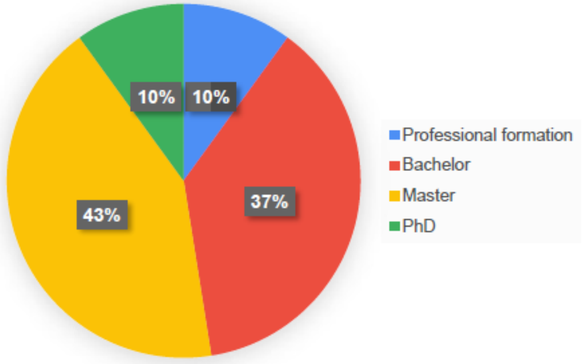
Who is interested, who is indifferent and who is disinterested?

Academic level

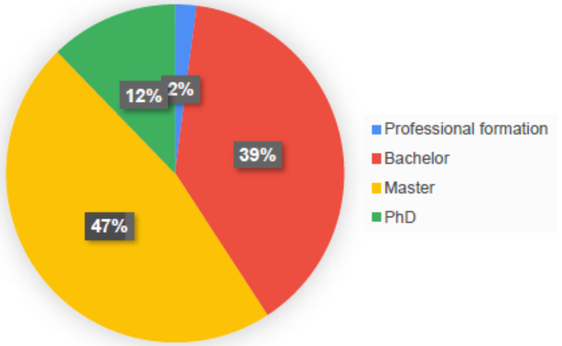
General results



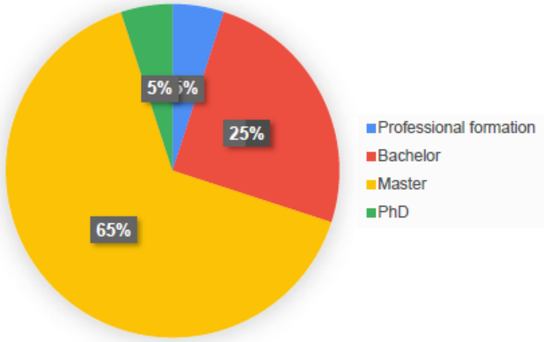
Group I: Interested people



Group II: Indifferent people



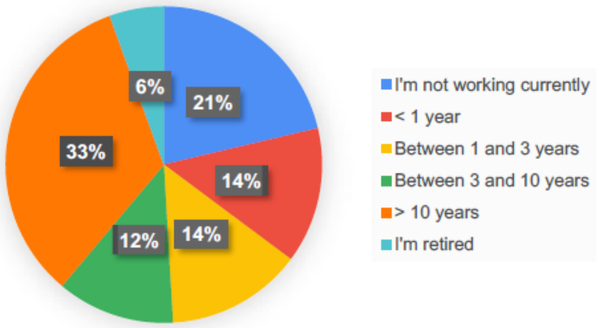
Group III: Disnterested people



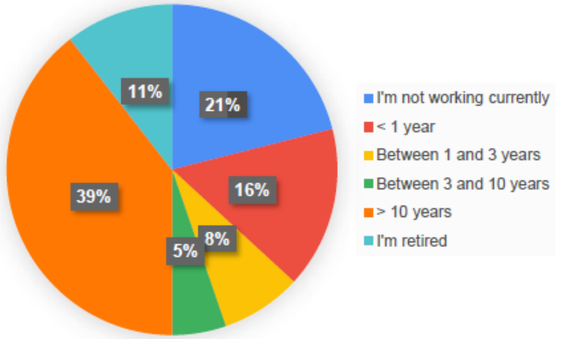
Who is interested, who is indifferent and who is disinterested?

Professional situation

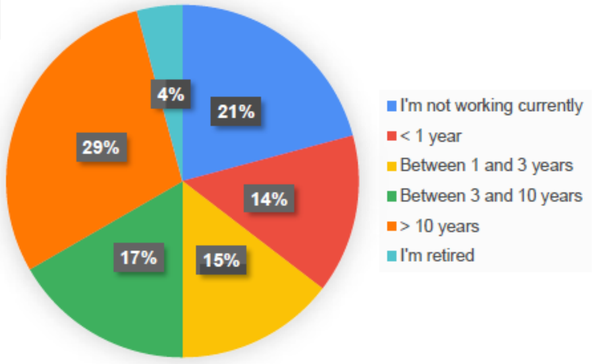
General results



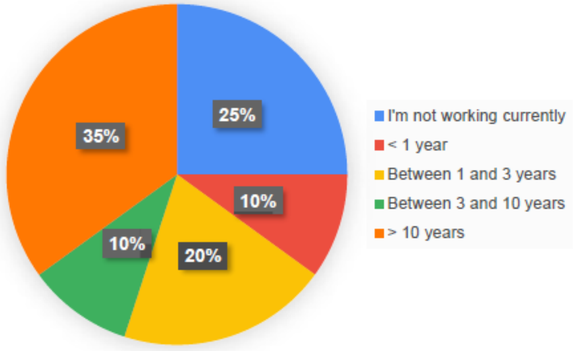
Group I: Interested people



Group II: Indifferent people



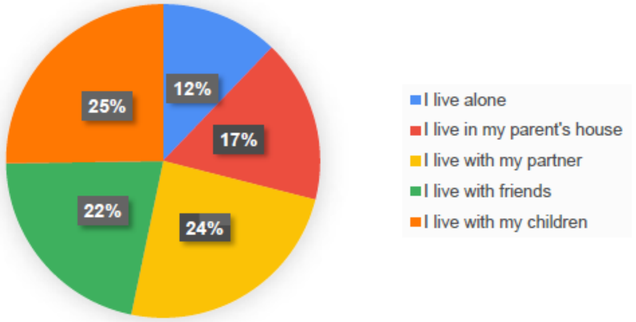
Group III: Disinterested people



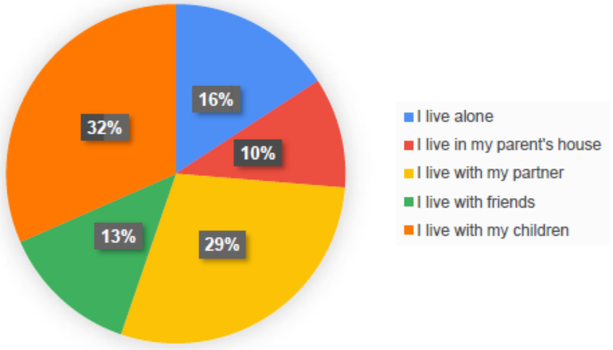
Who is interested, who is indifferent and who is disinterested?

Type of household

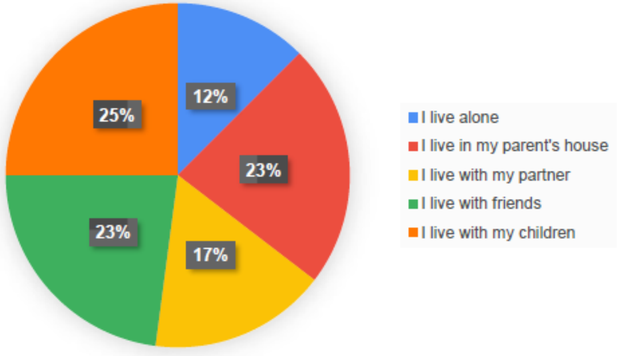
General results



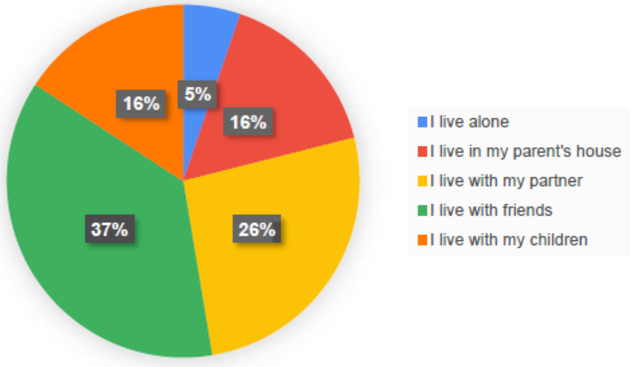
Group I: Interested people



Group II: Indifferent people



Group III: Disinterested people



Group of interested people

Demographic influence

Age:
> 35 years old (+13%)

Gender:
Female (+9%)

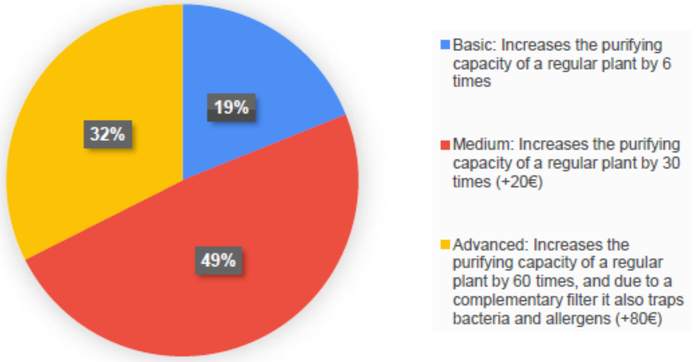
Professional situation:
>10 years (+6%)
Retired (+5%)
<1 year (+2%)
1 - 3 years (-6%)
3 - 10 years (-7%)

Type of household:
Children (+7%)
Partner (+5%)
Alone (+4%)
Parents (-7%)
Friends (-9%)

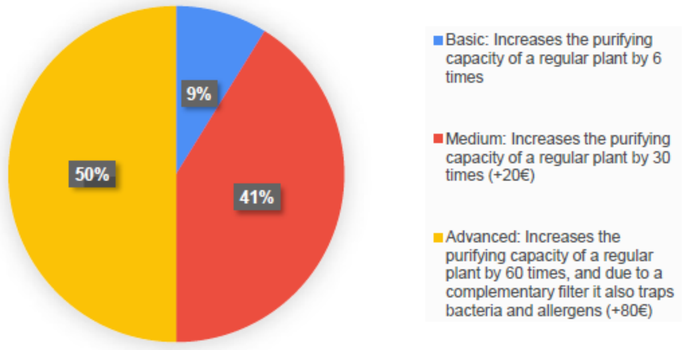
What preferences do they have?

Air purification technology

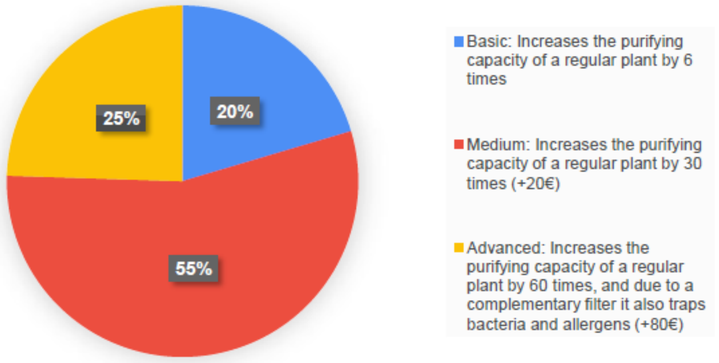
General results



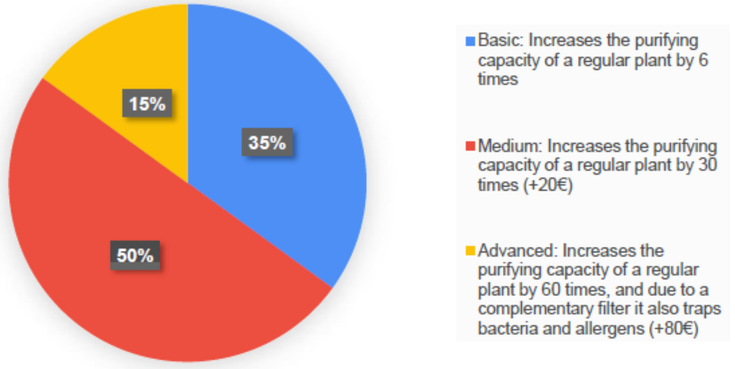
Group I: Interested people



Group II: Indifferent people



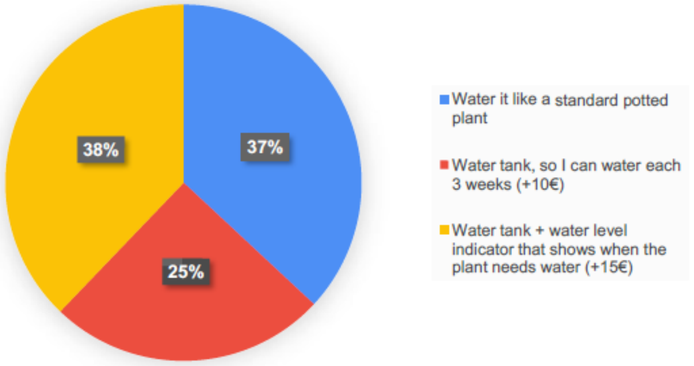
Group III: Disinterested people



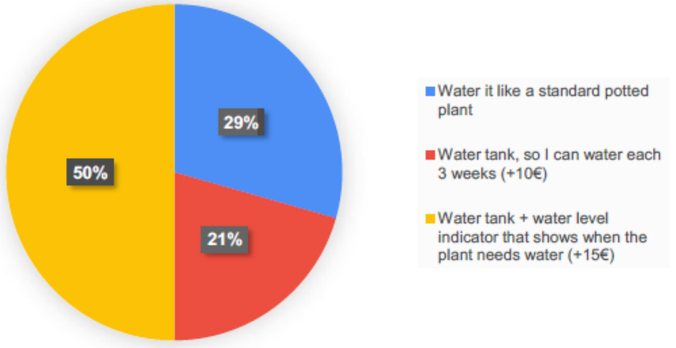
What preferences do they have?

Watering system

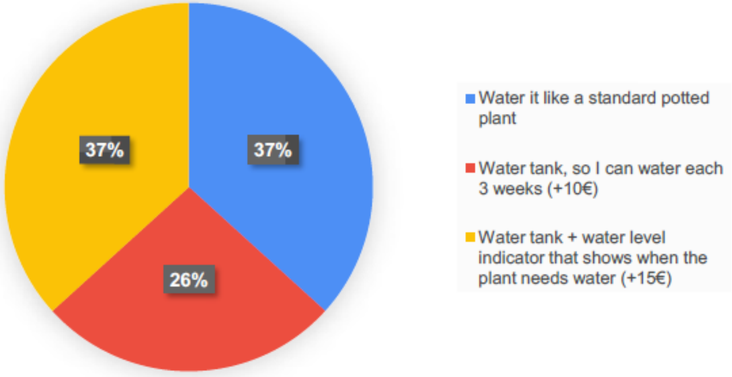
General results



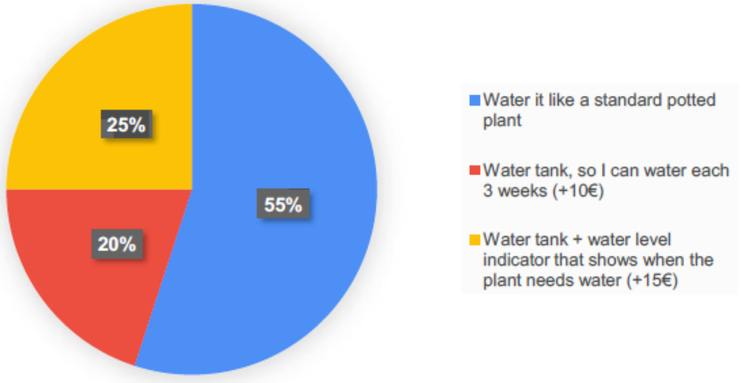
Group I: Interested people



Group II: Indifferent people



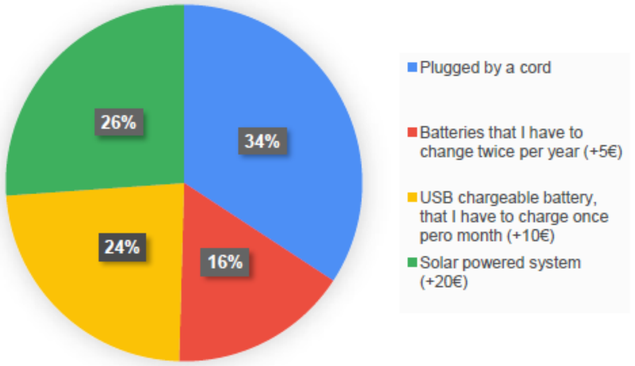
Group III: Disinterested people



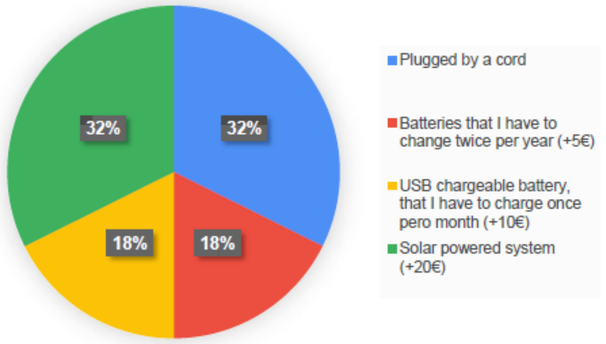
What preferences do they have?

Powering system

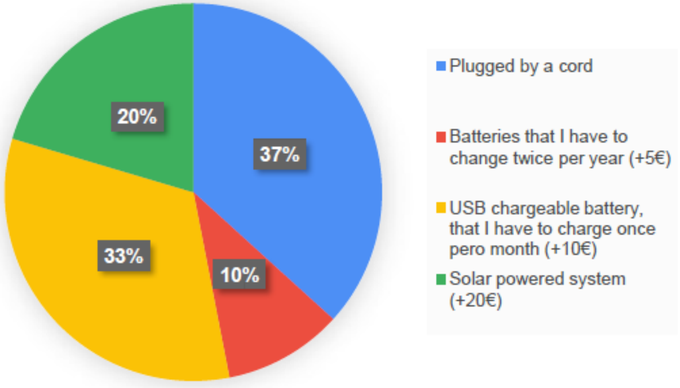
General results



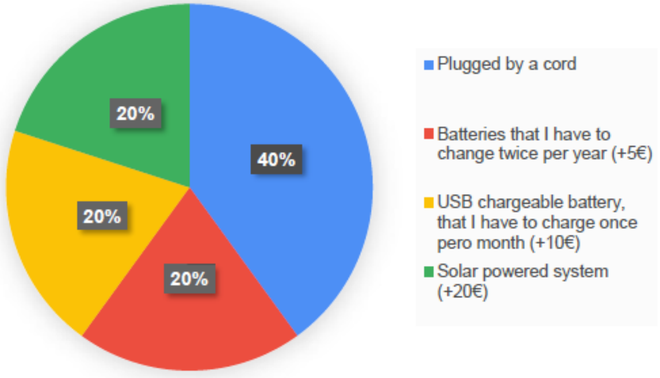
Group I: Interested people



Group II: Indifferent people



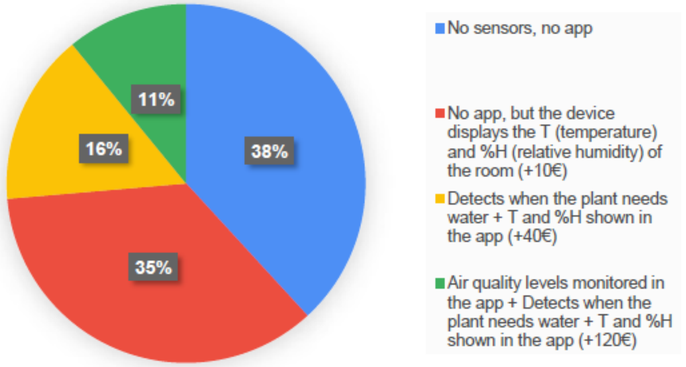
Group III: Disinterested people



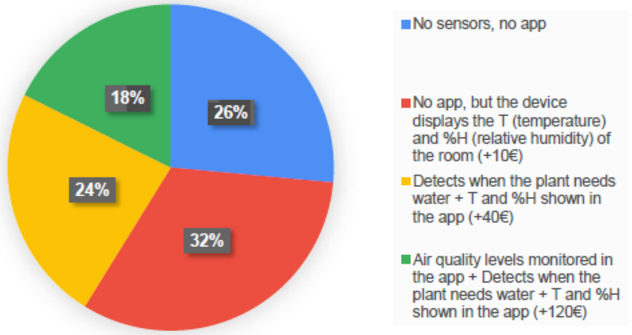
What preferences do they have?

Sensors connected to an app in your smartphone

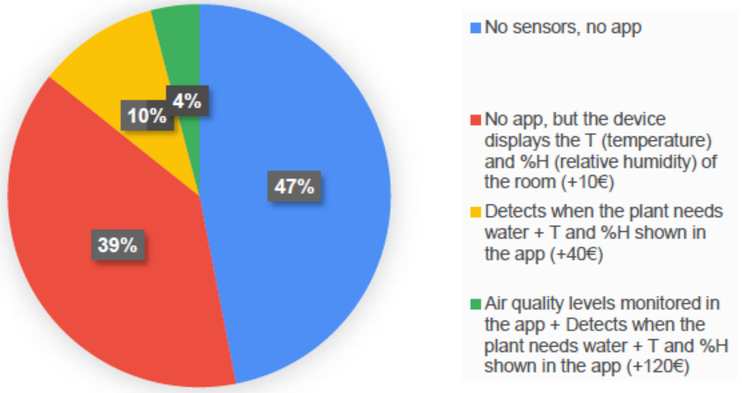
General results



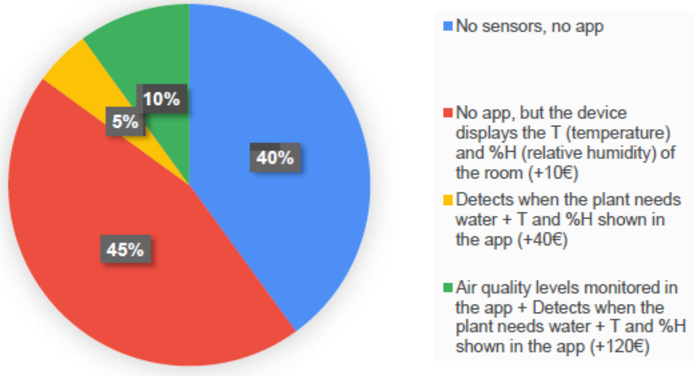
Group I: Interested people



Group II: Indifferent people

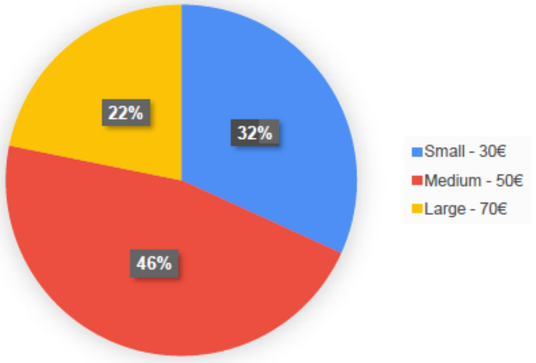


Group III: Disinterested people

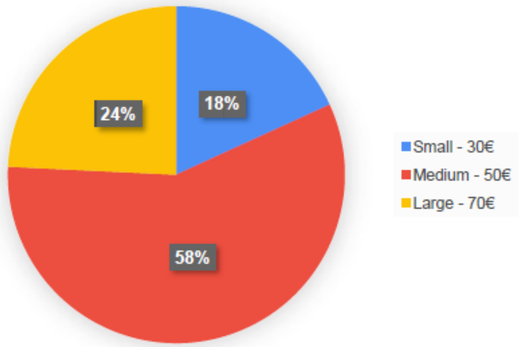


What preferences do they have? Size

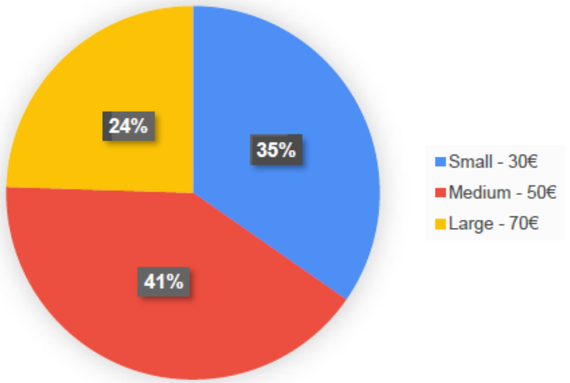
General results



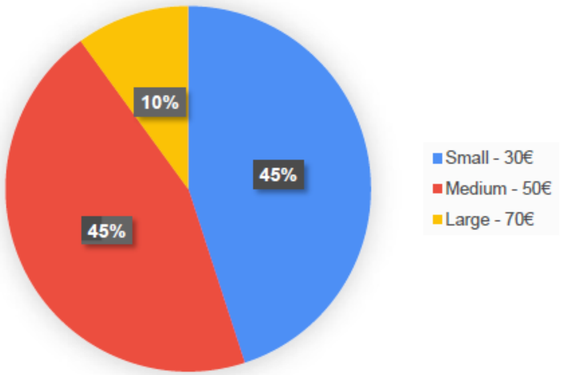
Group I: Interested people



Group II: Indifferent people



Group III: Disinterested people



What preferences do they have?

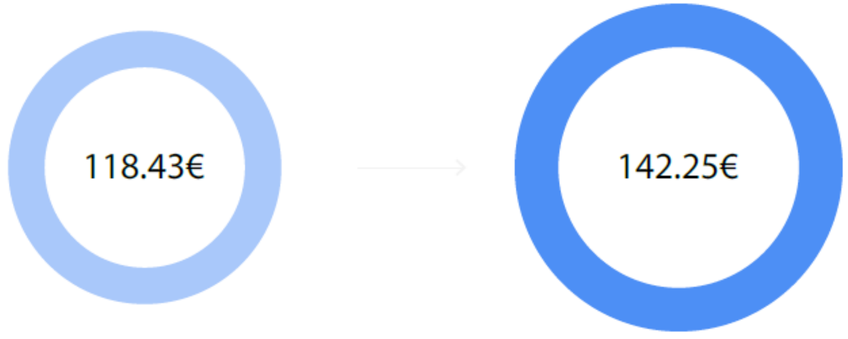
Price

General results

Average quantity to spend in increasing the “air quality of your space” (before doing the test)

Average price of the customized purifier (after the test)

Group I: Interested people



Average quantity to spend in increasing the “air quality of your space” (before doing the test)

Average price of the customized purifier (after the test)

Group II: Indifferent people

Average quantity to spend in increasing the “air quality of your space” (before doing the test)

Average price of the customized purifier (after the test)

Group III: Disinterested people

Average quantity to spend in increasing the “air quality of your space” (before doing the test)

Average price of the customized purifier (after the test)

Group of interested people

Demographic influence

Age:
> 35 years old (+13%)

Gender:
Female (+9%)

Professional situation:
>10 years (+6%)
Retired (+5%)
<1 year (+2%)
1 - 3 years (-6%)
3 - 10 years (-7%)

Type of household:
Children (+7%)
Partner (+5%)
Alone (+4%)
Parents (-7%)
Friends (-9%)

Preferences

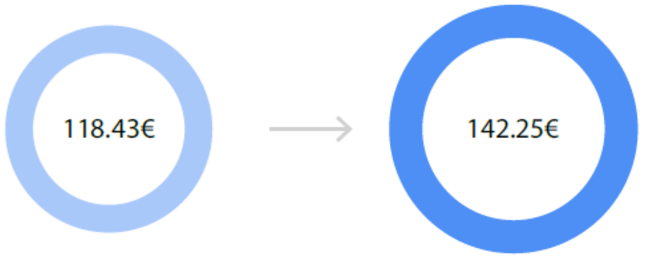
Air quality
50% Advanced
41% Medium
9% Basic

Watering
50% Level indicator
29% Normal plant
21% Water tank

Powering
32% Solar
32% Cable
18% Batteries
18% USB

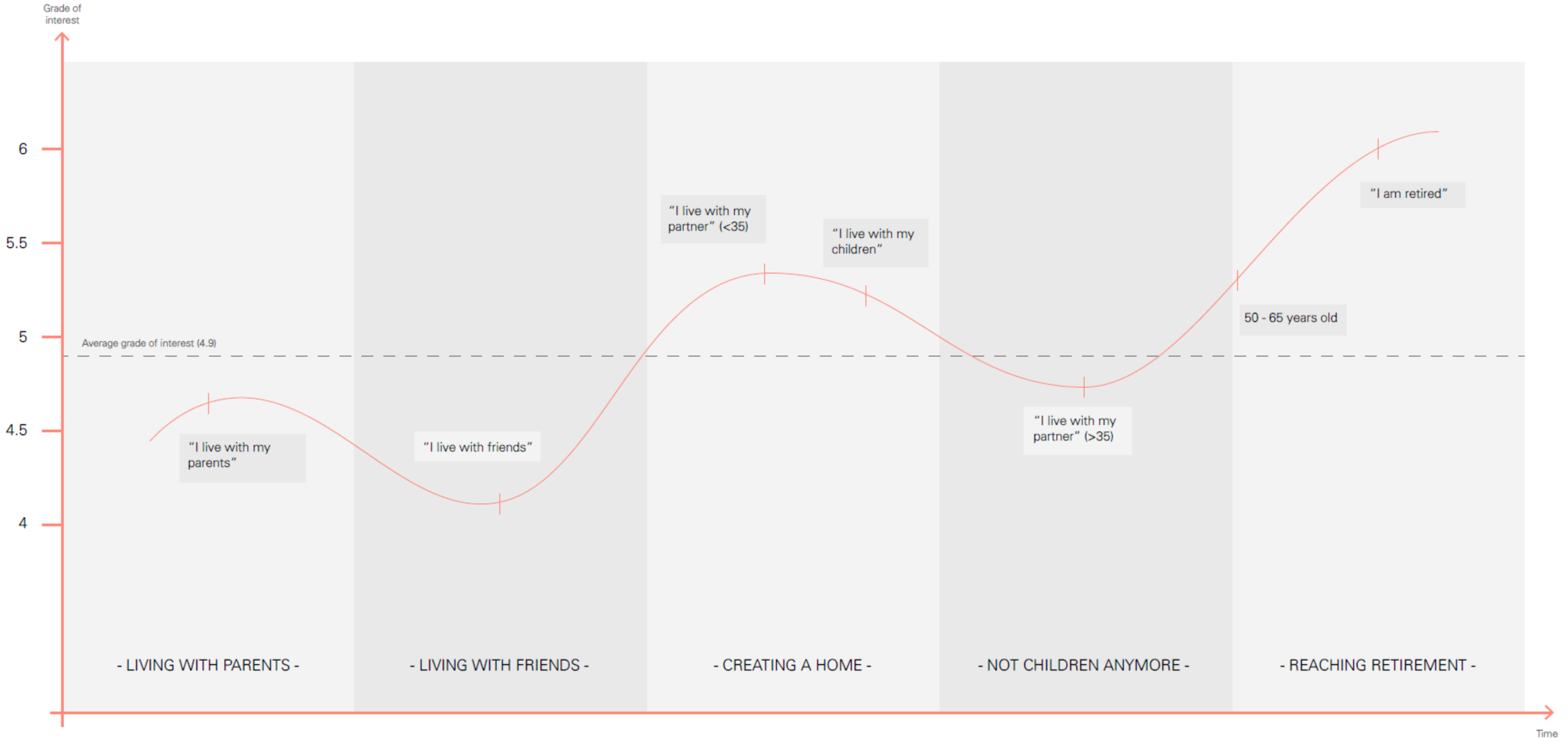
Monitoring
32% Displays T and %H
26% No sensors
24% Watering sensor
18% Air quality monitored

Size
58% Medium
24% Large
18% Small



Average interest per group

Interest timeline



/ Appendix 4: Target group interviews script

Interviews

0. Introduction:

/ I explain what kind of project I'm doing
/ I explain the purpose of the interview

1. Warming up questions

1a. What's your opinion on the current state of the air quality? Have you ever been concerned about it? Have you ever taken action against the problem?

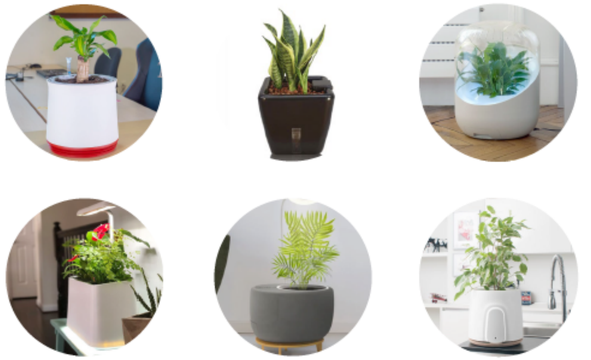
1b. Do you have plants? What drove you to get the plants? What do you enjoy from this experience?

2. Exercise 1: Buying in the market

/ I introduce the nature-based air purifiers, explaining the technology and the benefits of such a product

/ I explain the exercise: You have to go through the products that you can find currently in the market, choose your favourite 2 products, and your 2 less favourite ones.

/ Make the interviewee to go through the market-products-file, and let him know that he should think aloud and explain the reasoning behind his choices



2a. Once the exercise is done; Would you buy any of these product this year? Why not? If not now, at what point of your life do you think you would be closer to buy it?

3. Consumer personality + ecologism grade

3a. Main three hobbies
3b. Product that goes in combination with your identity
3c. Mainstream product that you don't like
3d. Prefered mean of transport
3e. Phone brand
3f. Gadgets that you use
3g. Dream holidays + perfect weekend
3h. If I give you 1000 euros, what would you do with them?
3i. What did you spend on your last 500 euros? Not basic needs

3j. Which habits do have do that you consider ecological
3k. Which habits do you have that you consider antiecological
3l. What's your opinion on eating meat?
3m. What's your opinion on taking flights?

4. Interest in the product

4a. Which option would be more correct for you?

(a)
1. I want to improve the air quality of my space
2. I want to buy an air purifier
3. Know about nature-based air purifiers
4. I prefer a nature-based air purifier

(b)
1. I want to buy some plants for my space
2. Know about nature-based air purifiers
3. I prefer to spend a bit more and buy it rather than just a plant

Interviews

5. Feeback on prototypes:

/ Show the interviewee the prototypes (real/visuals)

4a. If I had to continue designing this product for your needs, how would it be at the end? Go through the following areas

- Air quality technology
- Watering system
- Powering system
- Monitoring

6. Exercise 2: Choosing pot styles

5a. Is the aesthetics important for you?

5b. Choose your 3 favourite pot styles and your 3 less favourite ones.

1- Plastic

2 - Terracotta

3 - Modern

4 - Wicker

5 - Ceramic

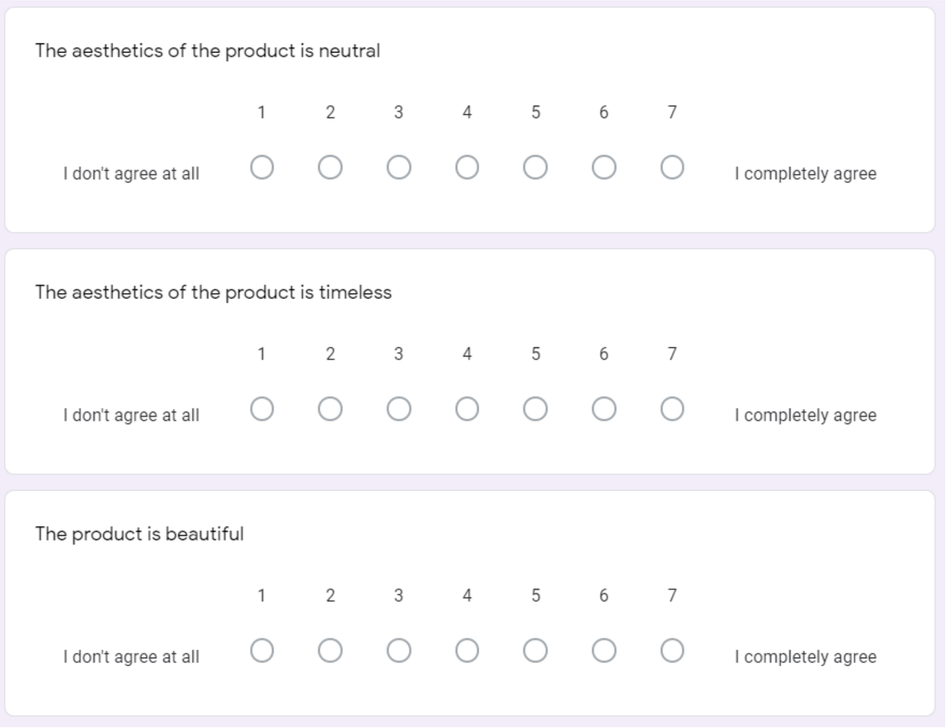
6 - Scandinavian

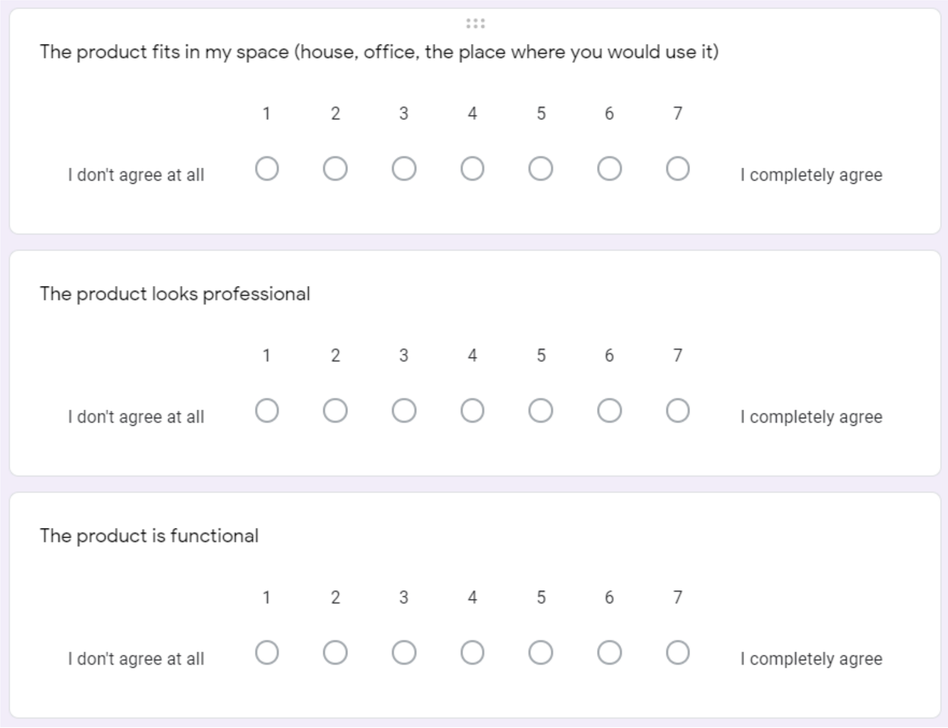
7 - Contrast

8 - Texturized

9 - Cork

/ Appendix 5: Looks and components configuration questionnaire





Select the option that you would be more interested in having at your place (home, office)

- 1
- 2
- 3
- 4
- 5

What do you like from this option?

Texto de respuesta larga

Select the option that you would be least interested in having at your place (home, office)

- 1
- 2
- 3
- 4
- 5

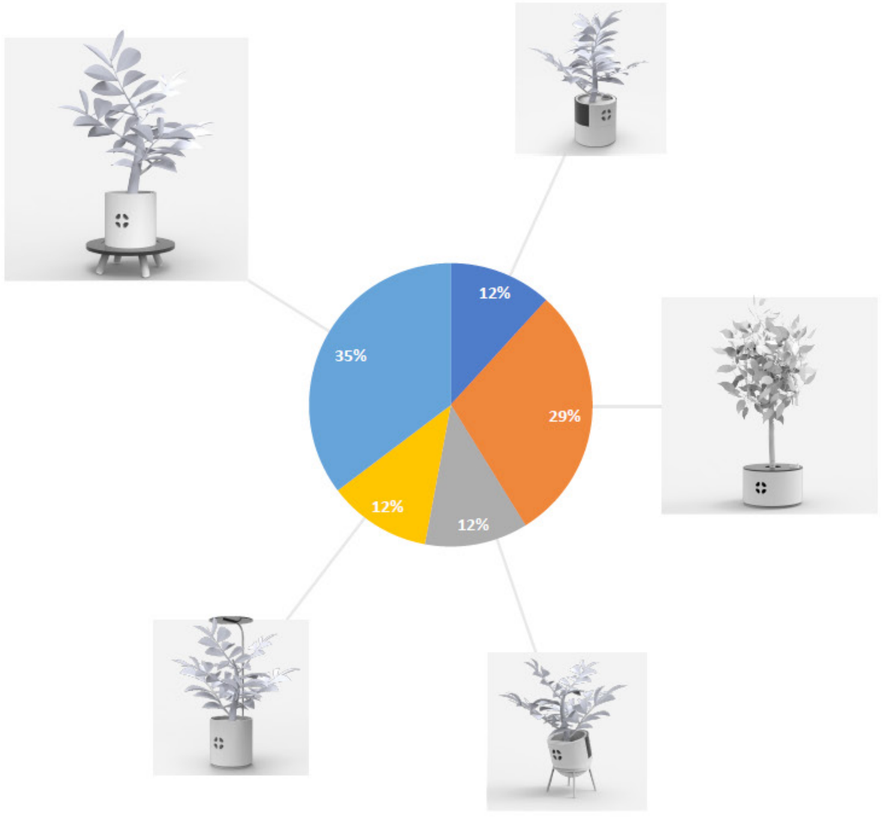
What do you dislike from this option?

Texto de respuesta larga

/ Appendix 5: Looks and components configuration questionnaire main results

Evaluation Questionnaire results

Select the option that you would be more interested in having at your place (house, office ...)



Select the option that you would be least interested in having at your place (house, office ...)