How might we make research around air quality as clear to the public as the air we want to breath?

FILTERED.

A solution to improving urban air quality by supplying public citizens with digestible, action-oriented, scientific air quality research.

JULY 2018

08.07.2018

URBAN AIR QUALITY CHALLENGE

A project of the Alliance for Collaborative Education (ACE) including Eindhoven University of Technology (Netherlands), OCAD University (Canada), Harvard University (USA), d.School Paris (France), Philadelphia and Thomas Jefferson University (USA), UTEC (Peru)

THE TEAM

_MARY BAUTISTA

_KATE GAFFIGAN

_EVAN QUADVLIEG

_PRIYANKA SUKUMAR

Contents

PART 1

Project Summary

As part of the ACE Urban Air Quality Challenge a multidisciplinary team of engineers, scientists, and designers were assembled to firstly identify and secondly present solutions to a problem framed within the larger and greater social challenge of how to improve urban air quality and scale that improvement. The project required both technical, field, and design research which were conducted primarily in the city of Eindhoven in The Netherlands and the city of Toronto in Ontario, Canada. The team was supported by coaches from Eindhoven University of Technology and OCAD University as well as academics and municipalities from both cities. The following report serves as a summary of all work completed on this project to date.

“[This] project addresses the complex problem of urban air quality taking into account the societal, economic, technological and anthropological context. The participants will be driven through the processes of understanding and proposing solutions to the complex problem of air pollution for specific case-studies.” ~ ACE Urban Air Quality Challenge Syllabus

PART 1

Project & Report Context

A major societal challenge of the 21st century is reducing the air pollution in urban areas, caused by anthropogenic activity. According to the Organization for Economic Cooperation and Development (OECD) air pollution is set to become the world's top environmental cause of premature mortality by 2050 in the case of no new policies being implemented (OECD, 2012). Despite its evident urgency, this subject has not yet been addressed as such in the eye of public awareness. This problem concerns us all, yet as stated in (Vugt, 2015): "It is widely accepted that we need to move toward greater environmental sustainability. Yet making the necessary changes has proved very difficult, in part because there are conflicting interests between relevant parties."

The quality of the air we breathe is an important condition for living a healthy life. Gas, particulate matter (PM) and organic components suspended in the air can have significant, though not immediately visible, health effects for everyone. Due to their vulnerability children, the elderly and persons suffering from respiratory problems are especially at risk. Providing citizens with clean air will be one of the greatest challenges for cities of all sizes in the years to come but has only recently been addressed as such. Different innovative solutions are needed to tackle the complex problem of air pollution. Citizens, air pollution experts, government and private companies must work together to develop successful solutions and regulations that support the maintenance of air and push for a global standard of universal clean air.

PART 1

Purpose of Report Project

This report summarizes the process taken to frame existing problems related to urban air quality in a manner that would allow for iterative solutioning to a final identified challenge.

We gained many new insights over the course of the project and our points of view changed several times accordingly. This has resulted in our solution space undergoing multiple changes as well. To reflect this iterative process, this report details the thought process and evolution of our research goals, approach, questions and plan. Part two will outline our initial take on Urban Air Quality and the solution proposed at that point in time. Moreover, this chapter will address how we arrived at our final solution by discussing our ideas with various experts in the field of regulation and academic research.

To conclude, part three will contain our end product. Here we will elaborate on its working principle, methodology, business model and validation based on questionnaires that were sent to people in our personal networks. Part 4 will speak to what we hope the future of this project holds and next steps we plan to take. The appendix contains the literature review that was done spanning international policy, air quality guidelines, visualization of the data we gathered during the first site visit and the self-reflection of each individual team member.

THE PROCESS

01
POST EINDHOVEN

02
PRE TORONTO

03
POST TORONTO

This project was executed over the course of three phases. The three phases loosely followed three scheduled site visits. The first and last site visits took place in Eindhoven, NL and the second site visit occurred in Toronto, ON. The following section summarizes the work completed during each phase. Several detailed results of our research during phases 1 and 2 can be found in the appendix of this report. Each summary includes the following:

_Research Methods & Insights
_Problem Statement
_Research Questions

PART 2

01

February 26, 2018 -
March 26, 2018

Post Site Visit
Eindhoven

Literature Review

Expert Interviews

Problem Finding

Site Measurements

02

February 26, 2018 -
March 26, 2018

Pre Site Visit Toronto
March 27, 2018
- April 27, 2018

Continued Literature Review
Expert Interviews
Problem Framing
Business Model Canvas & Value Proposition Canvas

03

February 26, 2018 -
March 26, 2018

Post Site Visit Toronto
April 27, 2018
- July 8, 2018

Solution Ideation & Iteration
Business Model Development
Customer Validation
Prototyping

PART 2

This project was executed over the course of three phases. The three phases loosely followed three scheduled site visits. The first and last site visits took place in Eindhoven, NL and the second site visit occurred in Toronto, ON. The following section summarizes the work completed during each phase. Detailed results of our research during phases 1 and 2 can be found in the appendix of this report.

01

February 26, 2018 - March 26, 2018

Post Site Visit Eindhoven

Literature Review

Expert Interviews

Problem Finding

Site Measurements

PART 2

Phase 1

Phase 1 Insights

- Air quality measurements cannot always communicate the scale of the issue
- Extensive policy exists globally to regulate the quality of the air in countries
- World guidelines around air quality and measurement are hard to comprehend and understand

Phase 1 Problem Statement

Air quality is one of the main environmental problems that affects global population's health and wellbeing. There is technology available to measure the air quality, but the means and ways for global cities and populations to comprehend that data are not popularized or easily scalable and transferable. We recognize that in order to put pressure on the bodies that govern and regulate air quality, the public must be informed. We have identified that problems exist at the intersection of citizens and the policies that impact their health as related to air quality.

Poor air quality in urban centers leads to the decreased health of citizens inhabiting urban centers. Improved air quality demands, among others: 1) new regulations and policy aimed at improving the air; 2) increased public awareness of the severity and scale of the problem and 3) human willingness to act.

Phase 1 Research Question

How can we create visibility of air quality to increase both public and government awareness that subsequently leads to civic action and policy innovation?

02

February 26, 2018 -
March 26, 2018

Pre Site Visit
Toronto

March 27, 2018
- April 27, 2018

Continued Literature Review

Expert Interviews

Problem Framing

Business Model Canvas & Value Proposition Canvas

PART 2

Phase 2

Phase 2 Insights

- Despite the risks polluted air quality entail there exists a detrimental lack of awareness of the issue
- There exists a lack of channels to properly communicate and raise awareness of the issue
- [We assumed at this point in the process that] a lack of awareness is directly related to the lack of air quality data that exists
- The way in which air quality data is visualized is vital to people understanding the data and how it impacts their life

Phase 2 Problem Statement

Based on the problem framing of phase 1, we understood that improved air quality demands, among others:

1) New regulations and policy aimed at improving the air;
2) Increased public awareness of the severity and scale of the problem
3) Human willingness to act.

Within these demands exist both technical and non-technical challenges of which our proposed solution space addresses. The technical challenge we have identified is the lack of proper air quality data and the non-technical challenge we have identified is the lack of a proper channel to provide awareness.

- Technical / Lack of data
- Non-technical / Lack of proper channel to provide awareness

Based on this problem statement we aimed to explore solutions to generating and processing scientific data connected the quality of air in urban centers.

Phase 2 Research Questions

Technical Sub-question:
How can we improve access to proper and real-time air quality data of urban center cities for effective use by citizens and government offices?

Non-technical Sub Question:
How can we improve the channel by which citizens and government access this data?

Solution Space Research Questions: (to be answered while researching in Toronto)

How might we implement/install/create sensors to improve real-time data measured?

How might we negotiate with privately owned transportation systems to leverage their infrastructure and networks?

How might open source data be valuable to citizens and changemakers?

What are our limitations with regard to the project scope? Of the solution? Of the system level innovation?

03

February 26, 2018 -
March 26, 2018

Solution Ideation & Iteration

Business Model Development

Customer Validation

Prototyping

Post Site Visit
Toronto

April 27, 2018
- July 8, 2018

PART 2

Phase 3

Phase 3 Insights

- It is easier to ignore and not act on a problem, if we do not know it exists
- There are overwhelming amounts of air quality data but a lack of communication of the findings to a broader audience
- Communicating the information has to be followed by giving people the OPTION of changing their behaviour
- The majority of citizens will only act after a personal tipping point has been reached

Key Insight = MERELY SHOWING DATA IS NOT ENOUGH

Key Insight = POLICY FORMATION IS HEAVILY INFLUENCED BY UNINFORMED PUBLIC

Key Insight = CITIZEN ACTIVISM IS UNDERMINED BY LACK OF KNOWLEDGE

The following final problem statement and final solution presented in the next section of the report reflect the problem statement and research questions of phase 3 of this project.

Primary Research Question:

How might we spread awareness of urban air quality in a way that empowers civic action, in favor of clean air?

Secondary Research Question 1:

How might we encourage and assist scientists in sharing their knowledge about air pollution with the general public?

Secondary Research Question 2:

How might we more effectively communicate scientific findings to the general public in a manner which allows them to take action against air pollution?

PART 3

THE SOLUTION

Final Problem Statement

Improving air quality demands, among others:

1) Scientific research to understand the implications of poor air quality
2) Increased public awareness of the severity and scale of the problem
3) Human willingness to act

Currently there exists:

- UNAWARE PUBLIC CITIZENS
- INEFFICIENT COMMUNICATION OF SCIENTIFIC FINDINGS
- LIMITED NUMBER OF INFORMED CALLS TO ACTIONS

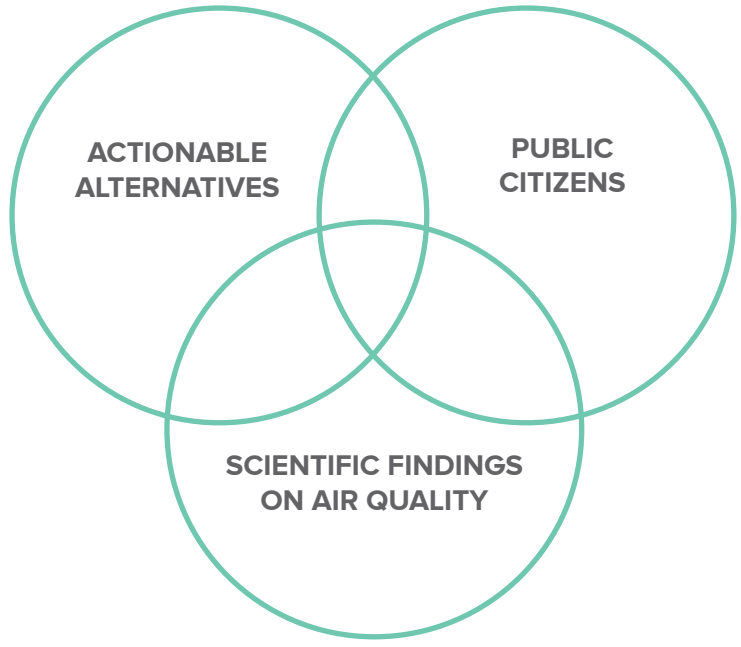
Why the need for actionable research?

If only actionable alternatives are provided to public citizens that are not supported by scientific findings on air quality then the public has a greater chance of making uninformed decisions.

If scientific findings on air quality produce actionable alternatives but are not made accessible to the public the result is an non-engaged public.

Currently, public citizens have access to scientific findings on air quality but are often left without actionable alternatives to implement in their daily life to combat air pollution. This leaves a large majority of scientific research as non-actionable research.

We believe the opportunity for change lies in a solution that addresses the current and large volume of scientific findings on air quality with the demand for actionable alternatives for public citizens to implement in their daily life and use to take action against air pollution.

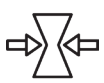


PART 3

Final Solution

We propose addressing our final problem statement and research questions with a methodology that will allow us to:

COLLECT SCIENTIFIC DATA



CONDENSE AND HIGHLIGHT THE MOST IMPORTANT FINDINGS

CONVEY IT TO THE PUBLIC WHILE PROVIDING ALTERNATIVES FOR ACTION

We aspire to improve urban air quality by supplying public citizens with easily understandable and action -oriented scientific research.

We aspire to be the link between expert scientist and the non-expert citizens. Our purpose is twofold. On one side, we collaborate closely with scientists. We help them communicate their scientific findings clearly and effectively, and we contribute to making their research more noticeable and recognizable to the non-expert public. On the other side, we provide a platform where citizens have access to accurate, easily understandable and action-oriented scientific information. Non-experts now have the tools to take action against air pollution based on scientific findings.

Business Model /

Customer Validation /

FILTERED Methodology /

Success Criteria /

Prototypes /

01 / Business Model Overview

Customer Segments
We have identified two customer segments for which we hope our solution will provide and deliver value to. Our two customer segments are 1) public citizens and 2) scientists.

Value Propositions
For scientists:
We aid in communicating their scientific findings clearly and effectively and provide a direct channel for their research to reach the public.

For public citizens:
We provide understandable scientific information that communicates:

1) the issue of air quality to the general public
2) provides actionable alternatives to combat air pollution in daily life

Channels
Our main channel by which our customers can acquire the value we provide them is through an electronic platform in the form of a website.

We acquire and retain our customers through several different marketing channels primarily social media and third party sites where our content can be delivered to pre-exisiting customer bases.

We deliver value to our scientists through our expert network.

Customer Relationships
The relationships and community we build with the scientific community is vital to the success of this model.

Revenue Streams
We have several different possible revenue streams. One potential revenue stream is to sell condensed content to third party competitors and partners.

Another potential revenue stream is selling access to scientific research to journalists.

Long term we will be able to sell our FILTERED methodology process to institutions looking to convey research to general public. Lastly we will collect in kind donations to support the maintenance of the platform from our customer base.

Key Partners
Universities and Research institutions
Journalists Communities
Third Party News or Popular Science Competitors

Cost Structure
TBD

Key Activities
Who are we hiring: someone in charge of looking for funding, digestors/assimilators, copywriters and editors

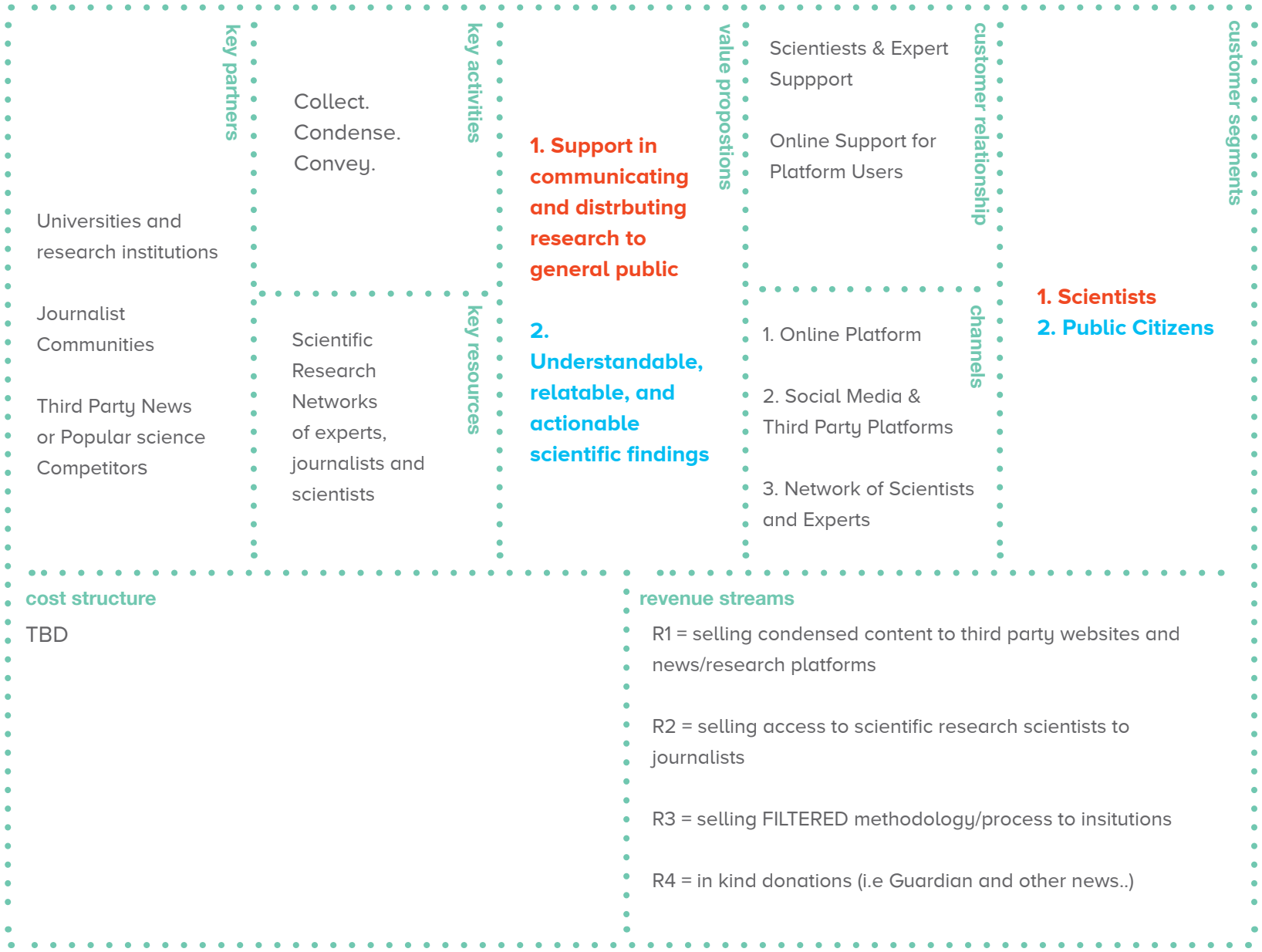
1. Build and foster relationships with scientists and the science community

2. Build and foster network of experts to contract out for specific FILTERED initiatives

3. Create and maintain platform

4. FILTERED Methodology : collect > condense > convey

Key Resources
Scientific Research
Networks of experts, journalists and scientists

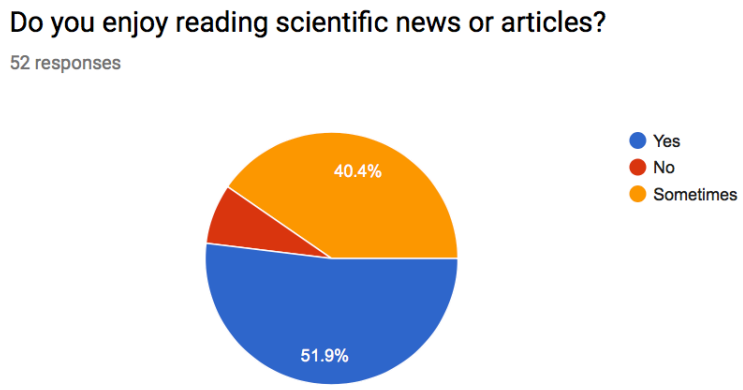

key partners
Universities and research institutions
Journalist Communities
Third Party News or Popular science Competitors
key activities
Collect.
Condense.
Convey.
key resources
Scientific Research Networks of experts, journalists and scientists
value propostions
1. Support in communicating and distrbuting research to general public
2. Understandable, relatable, and actionable scientific findings
customer relationship
Scientiests & Expert Suppport
Online Support for Platform Users
channels
1. Online Platform
2. Social Media & Third Party Platforms
3. Network of Scientists and Experts
customer segments
1. Scientists
2. Public Citizens
cost structure
TBD
revenue streams
R1 = selling condensed content to third party websites and news/research platforms
R2 = selling access to scientific research scientists to journalists
R3 = selling FILTERED methodology/process to insitutions
R4 = in kind donations (i.e Guardian and other news..)

02 / Customer Validation

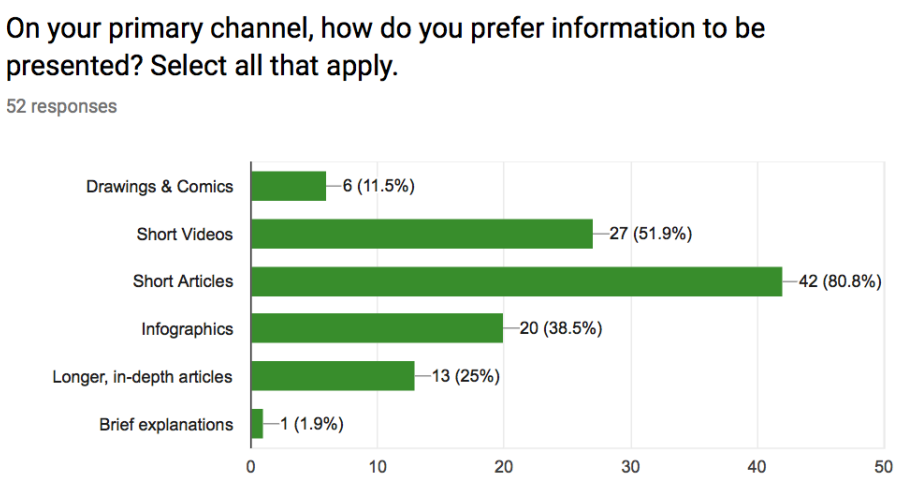
Our business model includes two separate customer segments, the public citizens and the scientists, therefore, the validation of the business model had to be carried out separately for both of those demographics. The following links will take you to the validation questionnaires which were sent out separately to non-experts and experts all around the globe:

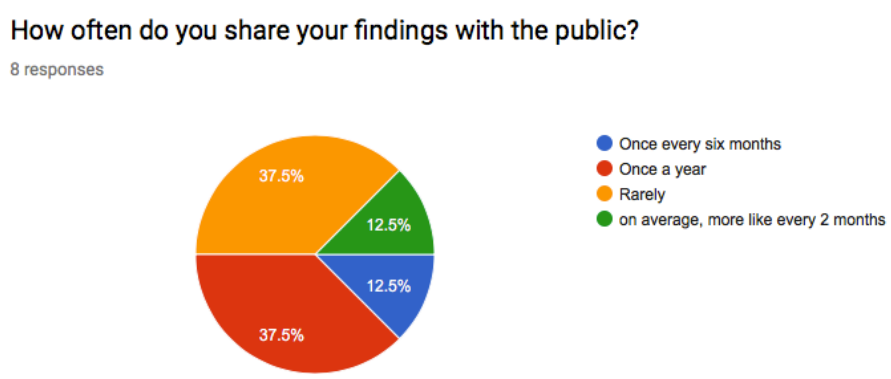
Citizen questionnaire: https://goo.gl/forms/4pQrR28BVZBH5ESH2
Scientist questionnaire: https://goo.gl/forms/haWx0dzUnOLRLmJ12

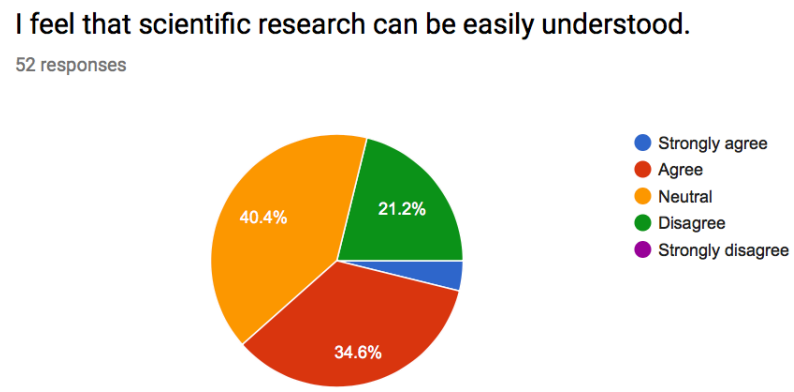
The Citizen survey was answered mostly by students below the age of 25 (~ 60%), and secondly by 25-45 year old working professionals (~ 30%). This mostly reflects the demographics of our current networks. The following pages showcase some of the most interesting insights from our conducted surveys.



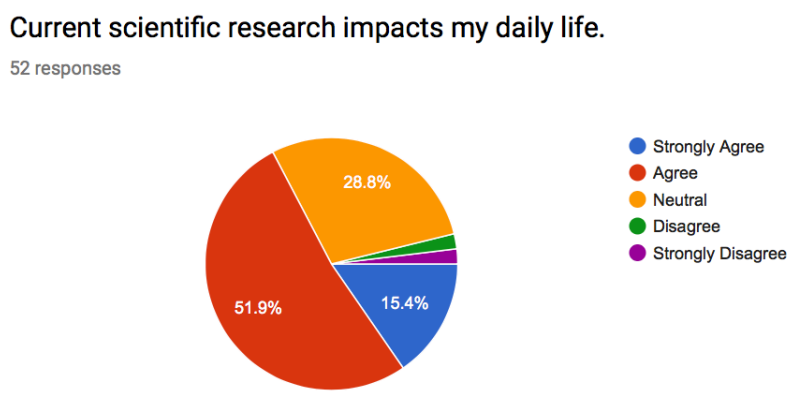
From the citizen survey, we verified that public citizens are interested in science, and they mostly prefer short articles, short videos or infographics to learn about scientific information. However, the public also expressed that scientific research is not always easy to understand, specifically, 80% mentioned that the use of scientific language and terminology is the most important challenge they faced when trying to understand scientific findings. Another important conclusion was that only around 50% of the people that completed the survey believed that science research plays an important role in their daily lives.







The scientist survey was sent to researchers from different areas of expertise. The main conclusions drawn from their answers were that scientists are eager and willing to share their findings to the general public, and they believe it is an important part of their job as a scientist. However, they expressed that sharing their results is not always easy. The main difficulties express were finding the time to do it and not receiving support, incentive or encouragement from the community (nor financial, nor public recognition, etc.). For these and other reasons, scientists do not publish or share their knowledge with non-experts.



03 / FILTERED Methodology

After validating our business model with the citizen and scientist surveys, we developed a procedure that we named FILTERED. This methodology assist us to collect, condense and convey scientific research to the non-experts.

COLLECT

Find a scientist or a journal article that could provide insightful knowledge to public. This can be done by a simple internet search: reading the abstracts from science journals, visiting the researchers website and/or, in the future, by tapping on to our scientist network and air quality knowledge database.

The four I's (See Appendix - Literature Review - Social Psychology Theory Section) could be used as indicators in identifying potential papers for condensation: a paper with content relating to 3 out of 4 I's stands a higher chance of being suitable for condensation than a paper without this connection. Additionally the more I's we can incorporate in our condensed article, the more likely it is to stick with people and lead to action being taken.

Another selection criteria that we could use to select a paper is "Altmetric" (https://www.altmetric.com/about-our-data/how-it-works/) a platform that monitors non-traditional sources (e.g tweeter, Mendely, ...) and measures the attention that a scientific article is getting. Popular scientific papers can be suggested for digestion/assimilation. This is an example of how Altmetric works from the British Journal of Sports Medicine: https://bmj.altmetric.com/details/1427829#score

CONDENSE

1. First contact with the scientist:

- Explain our idea:
- Idea of them reviewing
- Pointing out that it is a limited amount of work for them

Their benefit: make their research more easily communicable/understandable.
Our benefit: raise awareness about air pollution

2. Become familiar with the scientist work/article.

- If the article that we want to condense is not freely available, we can contact the scientist and ask for an interview or a copy of his/her article.

3. Summarize with our words the scientist work and do a first draft of our piece.

4. Second contact with the scientist:

- Ask for feedback, possibly ask to provide some non-copyright figures for the piece, suggestions, etc...

5. Repeat until all parties are satisfied

CONVEY

1. Produce the final piece and ask for final scientist approval.

- We will not just creating news articles. For each of our pieces, we will commit a considerable amount of effort in close collaboration with the scientist. We will not publish anything that has not been fully approved by a recognised scientist. No fake news, misleading information or sensationalism.

2. Upload it on the webpage with a link to the journal article and scientist webpage.

3. Share it through social media (i.e. Facebook page and twitter) and through channels like the “Dare to CAIR” awareness campaign (https://twitter.com/daretocair). Additionally, we could explore channels like Global Citizen (https://www.globalcitizen.org/en/) which its well developed and engaged community can help us draw attention to our webpage platform.

In the future, we would like to include translations of our pieces, to be more inclusive to people that do not speak English like indigenous communities.

04 / Success Criteria

A crucial aspect to the success of our platform is the effectiveness of our FILTERED methodology. Understanding what is needed in a message for someone to both accept and act on it will allow us to shape our articles more purposefully. The factors underlying both acceptance of and compliance to a message have been the subject of various studies in the field of social psychology. However, as our messages are specifically aimed at promoting behaviour beneficial to ourselves and our environment, they must include aspects that specifically influence the acceptance and promotion of environmental messages. The concepts from social psychology can help us achieve it. For a more detailed explanation of these concepts please refer to Appendix - Literature Review - Social Psychology Theory and the references within.

For the project to be successful, each FILTERED piece we must try to address the “four I’s” or four core motives for decision making in social dilemmas: understanding, belonging, trusting, and self-enhancing. These motives are fundamental psychological processes that have most likely been shaped by evolutionary selection pressures that influence our thinking, feeling, and behaving in social interactions.

05 / Prototypes

We worked simultaneously in three different scientific articles to produce our first prototypes for the website. Those pieces are still a work in progress, they are not ready yet to be published on the website, they have not been approved by the scientists.

The following pages feature one collected, condensed and conveyed prototype:

Blocken et al. (2016) :
https://docs.google.com/document/d/1RPwdmojNQDTKrUYbkqFYV9Org8tts32goAr5QQTgwLc/edit?usp=sharing


A. 2 C.
HOME
ABOUT
EXPLORE
GLOSSARY
CONTACT
ACCUMULATION 2 COMMUNICATION
COLLECTED.CONDENSED.CONVEYED.

We are the link between expert scientist and the non-expert citizens. Our purpose is twofold. On one side, we collaborate closely with scientists. We help them communicate their scientific findings clearly and effectively, and we contribute to making their research more noticeable and recognizable to the non-expert public. On the other side, we provide a platform where citizens have access to accurate, easily understandable and action-oriented scientific information. Non-experts now have the tools to take action against air pollution based on scientific findings.

Do you know what you breath in a parking garage?

Blocken, et al. Reduction of outdoor particulate matter concentrations by local removal in semi-enclosed parking garages: A preliminary case study for Eindhoven city center. J. Wind Eng. Ind. Aerodyn. 159 (2016) 80–98

Key Takeaways

Air quality is a major problem in urban areas. "Traffic is one of the main sources of particulate matter (PM) inside urban areas." "While Air quality is a major problem in urban areas. "Traffic is one of the main sources of particulate matter (PM) inside urban areas." "While large particles when inhaled can be filtered in the nose and throat, particles smaller than about 10 micrometer (PM10) can settle in the bronchi and lungs. Particles smaller than 2.5 micrometer (PM2.5) can reach the alveoli, and particles less than 100 nanometer can pass through the lungs to other organs including the brain. Many studies have linked PM to lung cancer, respiratory, cardiovascular and cardiopulmonary diseases,..., Alzheimer's and Parkinson's disease pathology, … while others have demonstrated the impact on birth outcomes.."

"Traffic-related PM includes brake dust, tire wear and tailpipe emissions" "Local traffic-related PM concentrations are influenced by a wide range of parameters including urban and building geometry, traffic intensity and meteorological conditions."

Action Checklist

- [ ] **Try to minimize as much as possible the time spent looking for a parking spot to avoid polluting and being exposed to pollutants.**
- [ ] **Close your car ventilation system and windows when driving inside an enclosed parking garage to reduce exposure to more polluted air located inside.**
- [ ] **Keep in mind that living/working next to a semi-enclosed parking garage ventilation system can have big implications on the air you breathe. As well as possibly having a PM removal unit install near you.**

If you want more details about this study:


A. 2 C.
HOME
ABOUT
EXPLORE
GLOSSARY
CONTACT
ABOUT
A. 2 C.
ACCUMULATION TO COMMUNICATION
We are an international and transdisciplinary team of engineers, scientists, and designers concerned about the urban air quality. Our team is part of the first Urban Air Quality Challenge, a project of the Alliance for Collaborative Education (ACE) including Eindhoven University of Technology (Netherlands), OCAD University (Canada), Harvard University (USA), d. School Paris (France), Philadelphia and Thomas Jefferson University (USA) and UTEC (Peru).
Breathe, learn, share and help us make a change!

PART 4

THE FUTURE

Project Conclusion

As part of the ACE Urban Air Quality Challenge a multidisciplinary team of engineers, scientists, and designers were assembled to firstly identify and secondly present solutions to a problem framed within the larger and greater social challenge of how to scalably improve urban air quality.

After an extensive period of research we arrived at a specific challenge. We wanted to explore solutions to how we might improve the visibility of air pollution to increase public awareness that might subsequently leads to civic action in favor of clean air. This in connection with exploring how we might better communicate science to the general public by empowering them with actionable alternatives to take daily to improve urban air quality.

With this challenge identified we executed several rounds of iterative solutioning to arrive at the solution proposed here in; an electronic platform that supplies the general public with current and up to date scientific research in a digestible format attached to a specific set of key actions that a citizen of any urban center can take to improve the air that they breath on a daily basis.

As previously mentioned the project required both technical, field, and design research which were conducted primarily in the city of Eindhoven in The Netherlands and the city of Toronto in Ontario, Canada. Our team was supported by coaches from Eindhoven University of Technology and OCAD University as well as academics and municipalities from both cities. This report serves as a summary of all work completed on this project to date.

Next Steps

The future of this work depends heavily on our ability to access the necessary resources to build team capacity required to implement a live prototype for testing and validating with customers. The following outlines next steps that would need to be taken into consideration for full implementation of the solution we are proposing as well as the maintenance and scalability of the aforementioned solution. This project stands to benefit from further funding to build team capacity, fully develop live prototypes in the form of a functioning website, build strong partnership networks and flush out a thorough business plan.

A number of steps must be taken to implement project development in the following project categories. We have identified these as our top priority areas but this is not an exhaustive list. Further resources would be needed to build out a full business and marketing strategy to create a more cohesive 3-5 year plan for full implementation and launch.

_Launch Full Beta Site
_Develop Scientist Network
_Develop Partnership Network
_Team Capacity Building
_Validate Desirability, Feasibility & Viability

Implementation & Funding Strategy

We envision the FILTERED business model to have three stages. Each state will focus slightly in different objectives, will employ different amount of people and will require different revenue streams. The ideal implementation road map will be the following:

Stage 1: Start-up
Timeline: 1-3 years

Objective: 25 articles in back log before officially launching the website platform

Processing Rate: Weekly releases of a FILTERED piece

Human Resources: 4 employees that will share the roles of: collectors experts, condensing expert, conveying experts and funding and business development.

Stage 2: Small-medium enterprise (SME)
Timeline: 3-10 years

Objective: Expand the network of expert who participate in FILTERED and start building a network of journalist that will want to collaborate with us and trust our FILTERED deliverables and “seal of approval”(See Revenue Streams).

Processing Rate: 10% annual increase in process rate

Human Resources: 10 employees that will share the roles of: collectors experts, condensing expert, conveying experts, business development and scientist management/recruiting.

Stage 3: SME with 10% annual growth

Timeline: 10-20 years

Objective: Expand the global network of scientist sand journalists Once our credibility has been established, we envision exploring long-term revenue streams

Processing Rate: steady 10% annual increase in process rate

Human Resources: 25 employees that will include: collection experts, condensing experts, conveying experts, business development and scientist management/recruiting personnel.

Stage 1 : Grants and awards funding

The air pollution problematic combines the knowledge from many areas of research. This gives us the opportunity to apply to grants and awards from different fields, including the health sector, urban planning, chemistry, ecology and biodiversity, physics, the automotive research, science journalism, among many others. Additionally, due to our diverse backgrounds, we could have access to grants, awards and funding from different countries, including: Canada, Netherlands, United States, India, Mexico and Chile.

We have gathered a list of possible organizations to which we could solicit funding via grants and awards. We will need to further analyze each option in more detail to verify if we comply with each of the requirements and deadlines. However, we found that many possibilities exist to seek funding. Some of the funding options worth taking into account are:

The NSERC Awards for Science Promotion (Canada) http://www.nserc-crsng.gc.ca/Prizes-Prix/SciencePromotion-PromotionScience/Index-Index_eng.asp
National Science Communication Institute (nSCI) (USA) http://nationalscience.org/project-portfolio/

CONACYT and the Mexican goverment (Mexico) https://www.conacyt.gob.mx/index.php/comunicacion/convocatorias-de-comunicacion-y-difusion-de-ciencia-y-tecnologia/convocatorias-abiertas-comunicacion

CONYCIT and Gobierno de Chile - Concurso de valoración y divulgación de la ciencia. (Chile - in Spanish) http://www.conicyt.cl/explora/xxii-concurso-de-valoracion-y-divulgacion-de-la-ciencia/

Rita Allen Foundation http://ritaallen.org/all-grants/ and http://ritaallen.org/misinformation-solutions-forum/

The Science Communication Awards of the American Institute of Physics (AIP) https://www.aip.org/aip/awards/science-communication

Society of environmental journalist https://www.sej.org/initiatives/awards-fellowships/non-SEJ-awards

Bill & Melinda Gates Foundation might have possibilities in the future https://gcgh.grandchallenges.org/grant-opportunities

National Geographic Society — Science Communication http://terravivagrants.org/national-geographic-society-science-communication/

Swiss National Science Foundation - Science communication support http://www.snf.ch/en/funding/science-communication/Pages/default.aspx

Knight Foundation https://www.knightfoundation.org/articles/knight-prototype-fund-seeks-early-stage-ideas-to-improve-the-flow-of-accurate-information

Other possibilities that might be worth exploring:

- Seeking financial support from University departments which do research in air pollution and might want to sponsor us. For example, we could ask Greg Evans from the University of Toronto for funding in exchange for digesting and sharing his team's research. This collaboration might help bring some visibility to the University and his research and maybe encourage future students to join his team.

- For each particular FILTERED piece, we could seek funding in different agencies. For example, we could ask the city of Eindhoven to sponsor the digestion of Blocken et al. (2016) scientific article which explains research carried out for that particular city. However, we should be careful not to have sponsors that might compromise the perception of our neutrality (i.e. Having Nike sponsor an article that promotes running in non-polluted areas).

- Ask for donations in our platform.

Before starting to formally seek for funding, we believe that is crucial to produce a couple of good pieces and our platform in order to have some good quality prototypes to show to the potential funding organizations. In addition, some of those funding options are only awarded for projects that have already started and are producing good results. We are aware that searching for funding is a demanding and time consuming job. Therefore, we might need to hire a person responsible for this part of the project. Additionally, most of the grants and awards only represent a small amount of money, so we believe, we will need to constantly be seeking for financial support or search for alternative and more sustainable long-term revenues for the following stages of the FILTERED project.

Stage 2: Journalist and “seal of approval”

We could explore at least two different revenue stream possibilities at this stage:

Journalist are constantly looking for scientific breakthroughs that might be of interest to their readers. However, not all journalist have the required science background to understand and properly convey scientific results. Often, journalist misinterpret the message a scientist is trying to convey or deliberately distort information to sell better sell their story. These actions result in many news articles that get published without the scientist complete approval and misinform the general public. We could explore the possibility of collaborating with scientist and journalist to provide a “seal of approval” that guarantees both parties that the scientific data is correctly interpreted and conveyed.
Following the previous idea, we could provide other online news platforms, on a regular basis, with FILTERED pieces which will carry our “seal of approval”.

Stage 3 : Long-term revenue streams

In order for the project to be successful, it is crucial to find long-term and viable revenue streams. We could cooperate with Universities and/or companies that try to introduce scientific breakthroughs to the business market and commercialize intellectual property. Investors, industrial partners and business entrepreneurs could benefit from our FILTERED methodology and our scientist network. One possible company that might be worth exploring is Oxford Science Innovation (https://www.oxford-sciencesinnovation.com).

Ideally in the future, if we manage to gather considerable funding, the FILTERED project could even pay the scientists a representative amount of money to recognize their effort and collaboration with us and also to encourage them to share their knowledge with the public.

Appendix

Contents

Literature Review

International Air Policies

India

It has been established in recent years that air pollution is the biggest environmental threat. Air pollution kills almost three million people a year. Among the top 50 cities in the world, India has 22 cities with the highest levels of $PM_{2.5}$. India is followed by China with 8 such cities [1]. The $PM_{2.5}$ concentration in Delhi exceeds the national air quality standard by 300% [2].

Policies & Laws in India

A list of the policies and laws that has been established before and after Independence are given below [3].

Laws Prior To The Independence Of India

1. The Oriental Gas Company Act, 1857
2. Indian Penal Code, 1860
3. Indian Explosive Act, 1884
4. The Bengal Smoke Nuisance Act, 1905
5. The Bombay Smoke Nuisance Act, 1905
6. The Indian Boilers Act, 1923
7. Indian Petroleum Act, 1934
8. The Motor Vehicles Act, 1939

Present Scenario

1. The Factories Act, 1948
2. The Industrial (Development and Regulation) Act, 1957
3. The Mines Act, 1952
4. The Inflammable Substances Act, 1952
5. The Atomic Energy Act, 1962
6. The Air (Prevention and Control of Pollution) Act, 1981
7. The Environment (Protection) act, 1986
8. Motor Vehicle Act, 1988
9. The Ozone Depleting Substances (Regulation and Control) Rules, 2000
10. The Municipal Solid Waste (Management and Handling) Rules, 2000
11. The Noise Pollution (Regulation and Control) Rules, 2000

Even though many policies have been formed, there has not yet been a significant reduction in air quality in Indian cities due to several technical and non-technical reasons.

The main technical reason includes the fact that the number of laboratories available for the analysis of pollutants/ chemicals is limited. Unavailability of proper technology to limit automotive pollutants is yet another major reason. The policy formations in India do not include the loss in economy due to air pollution. Another major factor is the difficulty in controlling the indoor air pollution which causes about 400,000–550,000 premature deaths. Furthermore, air quality in India is not monitored in a real time environment, most measurements are taken manually using outdated technology [3].

There are many non-technical reasons contributing to the lack of results and gaps in policy formation. The main reason for this is that, in India, it is the policy that comes first, and people only get to know about it later. The other reasons include the lack of motivation in the established agencies, the lack of awareness in communities and the minute amount of public engagement and participation [3]. It is almost impossible to get the people to pitch in and people refuse to use the public transport or even segregate the waste produced at home.

However, the main reason is that the governments fail to enforce proper measures. There are 94 cities in India which do not meet the air quality standard and not enough priority is given to air pollution by the government. The amount of time taken by the governments to make decisions and deal with environmental decisions is excessive and it lacks a proactive and involved decision making system [4].

There are many policies in place, but the extent to which they are implemented is very limited due to the vast amount of corruption happening within the country. The bureaucracy responsible for the implementation of these schemes is highly corrupt. Environment Protection Act, Air Pollution Act, Water Pollution Act, etc. which have been established in India have become a sham due to the massive amount of corruption. One of the main reasons for this is that, in India, the corruption happens at all levels unlike Western countries.

China

Air pollution is one of the major threat in China with only around 84 out of the 338 cities meeting the air quality standard. The $PM_{2.5}$ concentration in Beijing was 73 $\mu g/m^3$ according to the reports published in 2016. The various observations on the why the policies in China failed or became successful are presented below [5][6][7][8].

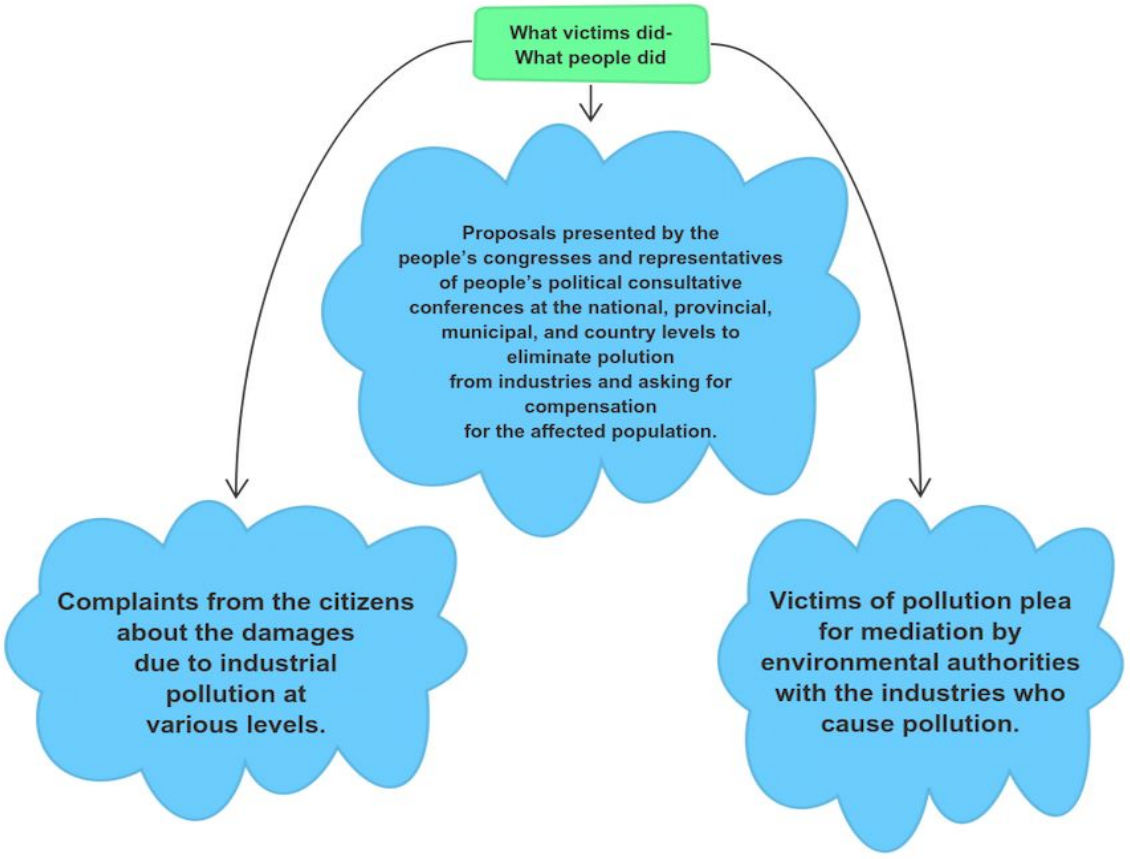


Figure 1. What citizens and victims of air pollution in China did in the mid 1990s

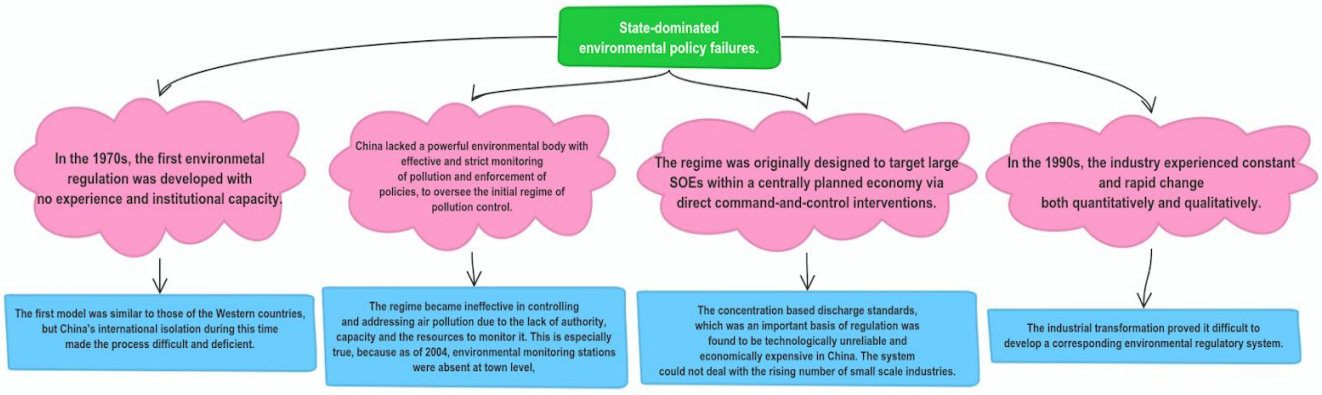


Figure 2: Chinese Policy Failures

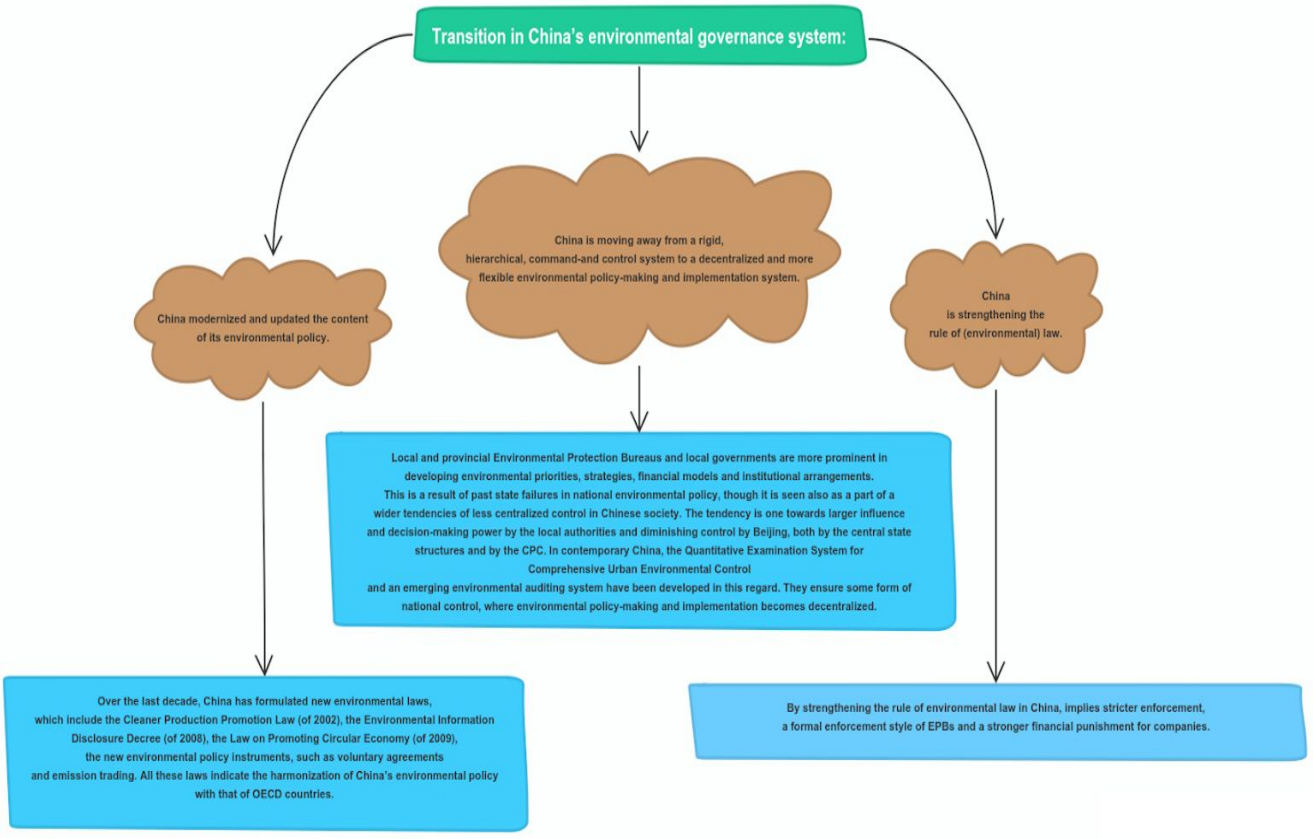
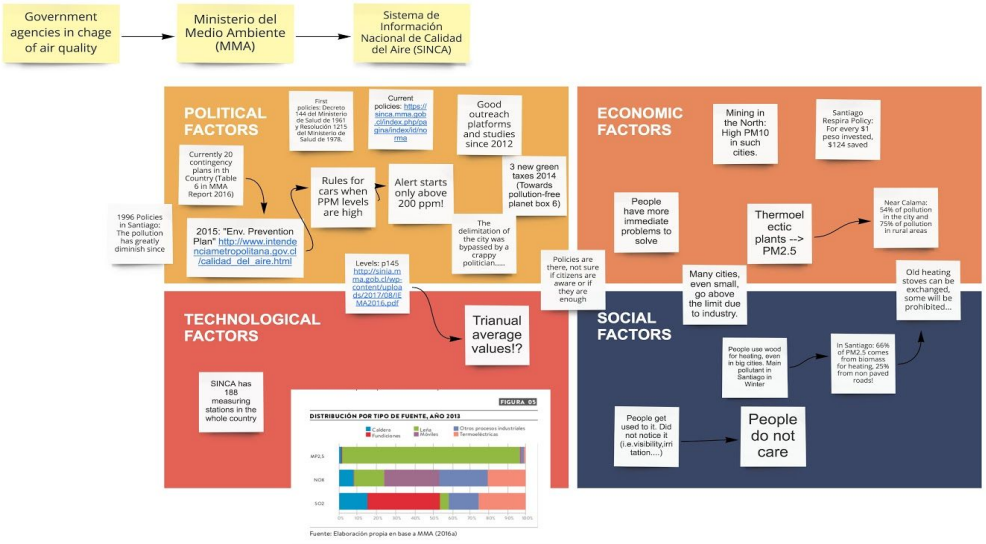


Figure 3: Why some policies became successful later

Chile and air quality

Visual summary and main ideas from the 2016 Report of the status of the environment from the National Minister of Environment in Chile [9]:.



Higher quality picture:
https://realtimeboard.com/app/board/o9J_kzwNCoc=/?moveToWidget=3074457346059877664

World Health Organization Air Quality Guidelines

The World Health Organization (WHO) ambient (outdoor) air quality guidelines [10] establish recommendation exposure limits for specific key air pollutants. Based on scientific evidence, such recommendations define the pollutants concentration levels at which adverse health effects can be significantly reduced. Nevertheless, even small levels of pollution appear to have an effect on health and an absolutely safe exposure limit to air pollutants does not seem to exist. For this reason, it is always preferable to minimization of air pollution even below the guideline values [10].

The WHO current guidelines are the outcome of a study carried out by the Regional European Offices, nevertheless, those exposure levels are suggested worldwide. Such guidelines are not legally binding, and it is up to every country/region to set up its own air quality standards and regulations. Unfortunately, local air quality standards vary greatly in various regions of the world. It is not only the exposure limit values that vary, but also their definition (i.e. different averaging time, different pollutants are taken into account, etc.). Additionally to avoid setting a goal that might be too

ambitious to reach, relaxed or interim air quality standards are set in an attempt to gradually achieve the guidelines' goal. All these different regulations can create confusion among the citizens and a bias perception on the air quality in certain regions. For the purpose of this work, the WHO guidelines will always be used as a reference.

Pollutant	**Main source [11]**	**Guideline WHO values [10] [$\mu g/m^3$]**	**Recent global trends [10]**
Particle Matter with diameter of 10 microns or less (**PM10**)	Suspended particles generated from agricultural and industrial processes, wood and fossil fuels combustion, construction activities, windblown dust and wildfires.	**20 µg/m³ annual mean** **50 µg/m³ 24-hour mean**	Concentrations levels have decreased mainly in Europe and USA. In Latin America and Asia it is still a major problem.
Particle Matter with diameter of 2.5 microns or less (**PM2.5**)	Suspended particles generated from agricultural and industrial processes, wood and fossil fuels combustion, construction activities, windblown dust and wildfires.	**10 µg/m³ annual mean** **25 µg/m³ 24-hour mean**	Concentrations levels have decreased mainly in Europe and USA. In Latin America and Asia it is still a major problem.
(Ground level) Ozone (**O_3**)	Photochemical reaction with nitrogen oxides	**100 µg/m³ 8-hour mean**	Average values have not decrease and in some places they have increased
Nitrogen dioxide (**NO_2**)	High temperature combustion i.e. heating, motors, and power generation	**40 µg/m³ annual mean** **200 µg/m³ 1-hour mean**	Average values have not decrease except in the USA
Sulfur dioxide (**SO_2**)	Burning of coal, petroleum, and other fossil fuels which contain sulfur, industrial processes and volcanoes	**20 µg/m³ 24-hour mean** **500 µg/m³ 10-minute mean**	Levels have decreased in most parts of the world, mainly because of the reduction of sulfur in fuels
Carbon monoxide (**CO**)[1]	Incomplete fuel combustion. Vehicles are the main source	**100 mg/m³ (90 ppm) 15-min** **60 mg/m³ (50 ppm) 30-minute** **30 mg/m³ (25 ppm) 1-hour** **10 mg/m³ (10 ppm) 8-hours**	

[1] Due to the lack of resources, the CO exposure limits were not included or updated in the current WHO air quality guideline. The previous guideline edition CO limits remain valid [12].

Expert Interview - Conversation with Lourdes Becerra

Lourdes Becerra is an Air Quality Researcher at Centro Mario Molina in Chile and previously worked in Mexico. She currently works on designing public policies to improve air quality and mitigate climate change. She focuses mainly on transport technology and quality of fuels. She is also involved in projects related to electric mobility and monitoring of air quality at low cost.

CHILE

- Over the last few years, the government started monitoring air pollution. It is still a big problem in Santiago, the capital, and in cities in the north where there is a large amount of mining business.

- Chileans are lagging behind compared to Europe or the US emission standards, but they are improving and they have more and better Regulations nowadays. It is one of the Latin American countries with less corruption and they are doing a good job at imposing those new regulations.

MEXICO

- It has one of the lowest quality fuel sources in the world. It had higher concentrations of sulphur, while other countries had already managed to reduce it.

- Motors and engines of lower quality cars sold in Mexico pollutes more compared with a car of the same model sold in Chile, Europe or the U.S. The emission standards imposed are outdated compared to the rest of the world.

- Having higher quality motors that pollute less is more expensive, so the automotive industry has no reason to sell more expensive cars since it is not required by law. Additionally higher quality motors require higher quality fuel to function properly. Since such fuels are not available in the country, car manufacturers do not want to sell high quality expensive cars that when there exists a shortage of high quality fuel.

- The most difficult problem to tackle in Mexico regarding air pollution and motor vehicles is the way the Federal government acts. The energy efficiency norms are really bad, outdated and hardly imposed. The government is highly influenced (not always legally) and highly dependent on the automotive manufactures and automotive industry lobbying. Additionally, there is a lot of corruption in the Mexican Petroleum company.

- Currently, many cities want to transition to electric vehicles and there are a lot of promises being made by uninformed politicians. However, there is a lack of understanding concerning the limitations of the electric vehicles (i.e. current electric buses on a hilly city most likely will

not be able to complete one route without recharging, ...) and the adequate infrastructure needed to provide electricity for vehicles (i.e. enough charging stations and an electric grid that can handle it). This lack of knowledge has become a major problem in many cities that started implementing an electric transportation system.

- Suggested to review the literature to discover what type of studies have been carried out with the measuring device that we used in Eindhoven.

- With regard to our project, Beccera mentioned that we need to be aware of how measurements are taken. City air quality measuring stations are placed at a determined and specific height in the atmosphere where a global measure of air pollution can be obtained. It represents a city wide value, for this reason, not many monitor stations are necessary.
    - ➔ Questions that came up after the interview: Do guideline values represent this type of measurements at high altitudes? Does that mean that local measurements will have higher concentrations? Does that mean guideline values can not be compared to more localised air quality measurements? **We need to ask further questions on the subject, but there is an important topic that we need to discuss and understand better.**

- Suggested references:
    - UN environment program: https://www.unenvironment.org
    - Climate and Air Coalition: http://ccacoalition.org/en
    - Global Fuel Economy Inicitaive (GFEI) - Tools for transportation studies : https://www.globalfueleconomy.org/in-country/gfei-toolkit
    - California Air Resources Board: https://www.arb.ca.gov/html/fslist.htm
    - 11th International Conference on Air Quality – Science and Application. http://www.airqualityconference.org

Science Communication

According to [13], it's important for scientists to be good communicators as it can help science become a part of the daily life for public citizens. In addition to letting public enjoy the various marvels of science, it can also help citizens, policy makers, funders etc. make informed decisions. It helps in educating the citizens about the various threats surrounding our planet and help in the creation of better and informed political and policy decisions. The communication of the scientific information by the scientists have certain 'measurable conservation impacts on the future of our planet'. The paper presents various innovative ways by which data can be communicated to the public to ensure that everyone is informed so that they can make decisions with a better understanding of the topic.

According to the author there are four main factors that leads to a separation between science and society, which makes it necessary for the scientists to involve the public audience. The four factors given in the paper are as follows:

- The loss of expertise and authority of scientists

- A change in the nature of knowledge production
- Improved communications and a proliferation of sources of information
- The democratic deficit.

The communication between science and society is basically described as a two-way street. Science is required by the society as a criterion for social, political and economic success whereas science needs the resources, talent and freedom from the society. And for the most effective communication, the scientist should present his findings taking into account the views and needs of the public.

The paper describes the term science communication as a communication not only between the science community and the public, but also as a communication between academia and industry, media, government and those in power and those who influence policy making.

View on Science Communication [13]

One of the methods of communicating science to these sections of population is described as an approach from three directions namely, communication (information transfer from scientific community to citizens), consultation (information transfer from public to scientific community) and participation (two-way communication between the public and scientists). Another three-way approach is to transmit (describe the ways to influence others decisions), receive (use other's knowledge and skill for one's own self-development) and collaborate (decide something together). An alternate style is to consider the role of public and experts combined with the content of discussion.

One of the most important criteria for the effective science communication involves the contribution of experts from multiple disciplines. To get the facts right we need the involvement of the scientist in the respective field; decision scientist to ensure that the important and the right facts are handpicked and highlighted and to ensure that the important facts are not missed; social and behavioral scientists to express and assess the communication; and communication practitioners to ensure the creation of a trusted channel.

Methods to communicate science [13]

The basic methods by which science can be communicated according to the author is through

a) conventional methods of journalism i.e. prints and broadcast
b) live or face to face events such as debates or public lectures
c) online communication which includes social media, wikis, blogs or internet sites.

The paper describes the various methods a scientist can adopt to make sure his work reaches the maximum number of audience. The various methods as stated in the paper are as follows:

- Establish a professional website
- Locate pertinent online conversations
- Navigate the deluge of online information
- Interact with diverse participants
- Reach your audience.

However, rationality and the ability to construct a dialogue with the public are considered to be the

most important two criteria. The paper also states some important rules to be followed while communicating science. Some of the rules to be followed are:

- To respect the factual truth
- To not disregard the possible negative consequences of the research [14]
- To not emphasize the results more than is rightful because a public that has been disappointed once, will be skeptical forever
- To not omit other options
- To declare possible conflicts of interest
- To be ethical, accountable and transparent

It is thus shown that it is necessary to have a collaboration structure between society and science as environmental problems like global warming etc. shadows the limitations between science, politics and society.

Social Psychology Theory

Descriptive social norms

In 2008 a multiyear study [15] was published which investigated the effectiveness of signs requesting hotel guests' participation in an environmental conservation program. The signs carried a message which urged guests to reuse their towels to help conserve environmental resources by saving energy and reducing the amount of detergent-related pollution. Traditionally, such a message (shown below) focused solely on stating the value and importance of environmental protection and this approach was standard throughout the hospitality industry.

"HELP SAVE THE ENVIRONMENT. You can
show your respect for nature and help save the environment
by reusing your towels during your stay."

However, this study showed that the incorporation of descriptive norms in these messages (example shown on the next page) significantly increased compliance. This type of social norm refers to the behaviour exhibited in a specific situation by the majority of people. This motivates a specific course of action by informing individuals of what is likely to be effective or desired behavior in that situation. These descriptive norms were found to be most effective if they related to a person's social identity or to their direct surroundings. The latter being called provincial norms—the norms of one's local setting and circumstances.

"JOIN YOUR FELLOW GUESTS
IN HELPING TO SAVE THE ENVIRONMENT. In a study conducted in Fall 2003, 75% of the guests who stayed in this room participated in our new resource savings program by using their towels more than once. You can join your fellow guests in this program to help save the environment by reusing your towels during your stay."

Figure 1 shows how appealing to the different identities of person invokes different levels of compliance. An important aspect of this graph is that the identities as a hotel guest and occupant of a specific room lead to more participation than the citizen or gender identity. The former two of these were shown to be the least important to the study participants, yet still resulted in the most participation. This can be explained by realising that individuals might be more likely to follow the norms of a social identity if that identity is provincial in nature. In other words, a message will be met with more compliance if it addresses the social identity that is the most relevant to a person in the moment that he or she reads it. An example of this would be to address a person's identity as a commuter in the article by Blocken that we have condensed. By activating the commuter identity and relating that to being in a parking garage, the chance of the reader acting on the message should be significantly higher.

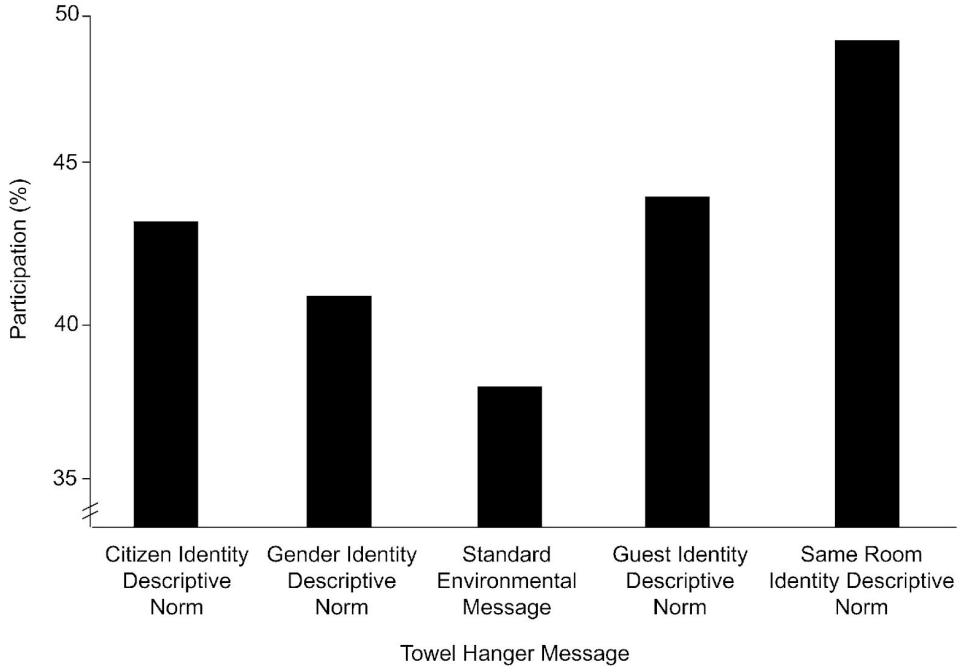


Figure 1: From [15]

The four I's

A 2015 study [16] suggests four key components of strategies for successful resource management: information, identity, institutions, and incentives. These four I's correspond to four core motives for decision making in social dilemmas: understanding, belonging, trusting, and self-enhancing (for an overview, see the table below). These motives are fundamental psychological processes that have most likely been shaped by evolutionary selection pressures that influence our thinking, feeling, and behaving in social interactions. The four I's could be used as indicators in identifying potential papers for condensation: a paper with content relating to 3 out of 4 I's stands a higher chance of being suitable for condensation than a paper without this connection. Additionally the more I's we can incorporate in our condensed article, the more likely it is to stick with people and lead to action being taken.

Four I's: Core Motives and Foci of Interventions for Successful Commons Resource Management and Potential Constraints

Focus of intervention	Core motive	Description	Aim of intervention	Potential constraint
Information	Understanding	The need to understand the physical and social environment	Reducing environmental and social uncertainty	Global environmental problems are inherently uncertain.
Identity	Belonging	The need for positive social identity	Improving and broadening one's sense of community	Resource competition between communities increases overuse.
Institutions	Trusting	The need to build trusting relationships	Increasing acceptance of commons rules and institutions	Authorities are not always seen as legitimate and fair.
Incentives	Self-Enhancing	The need to improve oneself and increase one's resources	Punishing overuse and rewarding responsible use	Economic incentives undermine intrinsic motivation to conserve.

Figure 2: Obtained from [16]

Information

People have a fundamental need to understand their environment to predict what will happen in case of uncertainties. However, this study states that "environmental uncertainty tends to promote overuse because most users are optimistic about the future and underestimate the damage they are doing to the environment". One angle could therefore be to specify local consequences of environmental change the condensed message. This could result in better understanding and more action being taken.

Identity

As a group-living species, humans have a deep sense of belonging to social groups. Research suggests that people easily identify with and form attachments to other individuals even in large groups. The strength of their social identity affects how much people are willing to conform to the norms of a particular group as well as they willingness to help their group or community in, for instance, protecting the environment. As stated in the section about descriptive social norms, addressing a person's social identity with a specific message can be a powerful persuasive technique.

Institutions

A third condition for successful management of a public resources such a clean air, is the presence of official institutions and authorities. These play a key role in governing local and global environmental resources and having confidence in the benevolence of other individuals and institutions lies at the heart of any collective effort to protect the environment. With this in mind, informing a reader about efforts being made by authorities might also increase their motivation and heighten their resolve in to make an effort themselves.

Incentives

There is no denying that many pro-environmental actions are driven by self-enhancing motives, notably the desire to seek rewards and avoid punishments. Monetary incentive schemes in the form of subsidies appear effective in fostering the adoption of home saving devices such as solar panels, water meters, and roof insulation. Our platform could also present readers with information about subsidies and programs such as the Dutch 'Fietsplan' (bicycle plan) initiative, which enables Dutch employees to take out a interest-free loan from their employer in order to buy a bicycle to commute

to work.

Literature Review References

[1] https://thewire.in/69268/air-pollution-who-india/
[2] “Traffic intervention” policy fails to mitigate air pollution in megacity Delhi;
Sourangsu Chowdhurya, Sagnik Deya, Sachchida Nand Tripathib, Gufran Beigc, Amit Kumar Mishrad, Sumit Sharmae.
[3] Air Pollution and Control Legislation in India. J. Inst. Eng. India Ser. A (July–September 2015) 96(3):259–265 DOI 10.1007/s40030-015-0125-z. Prashant P Bhave, Nikhil Kulkarni. The Institution of Engineers (India) 2015.
[4] https://thewire.in/16474/why-swacch-bharat-type-schemes-will-fail-in-india/
[5] Ministry of Environmental Protection of the People's Republic of China. May 9, 2017.
[6] Ma Jun (31 January 2007). "How participation can help China's ailing environment". Retrieved 28 July 2013.
[7] https://www.nytimes.com/2018/01/14/opinion/china-environmental-policies-wrong.html
[8]https://news.nationalgeographic.com/2017/05/china-air-pollution-solutions-environment-tangshan/
[9] "Informe del Estado del Medio Ambiente 2016 Versión en ... - SINIA." http://sinia.mma.gob.cl/wp-content/uploads/2017/08/IEMA2016.pdf. Accessed 19 Apr. 2018.
[10] WHO Regional Office for Europe. Air quality guidelines. Global update 2005. Particulate matter, ozone, nitrogen dioxide and sulfur dioxide. Webpage: "Global Update 2005 - WHO/Europe - World Health Organization." http://www.euro.who.int/__data/assets/pdf_file/0005/78638/E90038.pdf?ua=1%201/23/17. Accessed 16 Apr. 2018.
[11] "WHO | Ambient (outdoor) air quality and health." http://www.who.int/mediacentre/factsheets/fs313/en/. Accessed 16 Apr. 2018.
[12] Air quality guidelines for Europe, 2nd ed. Copenhagen, WHO Regional Office for Europe, 2000. WHO Regional Publications, European Series, No. 91
[13] Jucan, M. and Jucan, C. (2018). *The Power of Science Communication*.
[14] Carrada (2006)
[15] Noah J. Goldstein, Robert B. Cialdini, Vladas Griskevicius (2008). A Room with a Viewpoint: Using Social Norms to Motivate Environmental Conservation in Hotels.
[16] Mark Van Vugt (2009). Averting the Tragedy of the Commons- Using Social Psychological Science to Protect the Environment

Eindhoven Measurements, Data Analysis & Insights

As part of the Eindhoven visit in February 2018, gas concentration measurements were carried out. The levels of nitrogen dioxide (NO_2), carbon monoxide (CO), sulphur dioxide (SO_2) and ozone (O_3) were measured at several sites in the city (See Table 1 for details). The equipment used for the measurements was a Vaisala Air Quality transmitter AQT 400.

Date	Time in	Time out	Site	Location
2018-02-21	13:51	14:11	1	Green open area in the middle of TU/e campus. The Zwarte Doos, bar and cinema located on the TU/e Campus. Den Dolech 2
2018-02-21	14:21	14:42	2	Outside Eindhoven train station. Next to the bus station and taxi stand. Kennedyplein 101
2018-02-21	14:50	15:13	3	Outside an indoor parking garage. Bike and pedestrian lane in between a busy road and a parking garage, measured next to the main air vent. Boschdijktunnel
2018-02-21	15:20	15:42	4	Downtown walking street. Sidestreet (Vrijstraat) of the main shopping street next to one of the main roads (Emmasingel) going around the city center. The corner of Vrijstraat and Emmasingel
2018-02-21	15:52	16:14	5	Main square in front of City Hall. Located on top of a parking garage and adjacent to the Emmasingel.
2018-02-21	16:27	16:44	6	Busy road intersection. During rush hour at the intersection of the Vestdijk and Kanaalstraat, in the middle of the road between road barriers.
2018-02-21	16:56	17:05	7	At the intersection of the Vestdijk and 18 Septemberplein, south of the train station.
2018-02-21	17:16	17:31	8	Small green area/park in the middle of a busy intersection and important roads. Bowling pins. Rush hour.
2018-02-22	09:30	09:50	9	Small green area/park in the middle of a busy intersection and important roads. Bowling pins. Same point as the day before but this time not during rush hour.

2018-02-22	09:56	10:22	10	Inside the train station.
2018-02-22	10:44	11:05	11	Kindergarten playground. Next to a busy intersection.
2018-02-22	11:16	11:33	12	Next to an elderly home. Next to a small and not so busy one-way street.
2018-02-22	11:45	12:04	13	Shopping and market area. Next to an outdoor parking and a somehow busy one-way street. Kruisstraat+ Verwesstraat.

Table 1: Measurement sites location during the first Eindhoven visit.

In order to reach the general public, create awareness and inspire change, non-expert citizens and government officials need to be able to understand findings from scientific studies. Conveying the information regarding these findings in an effective and proper manner is therefore one of the main challenges that we need to tackle in this project. We decided to explore different ways to understand and present the data gathered from the gas concentration measurements taken during the Eindhoven site visit. The data obtained with the on-site measurements can be visualized in the following figures.

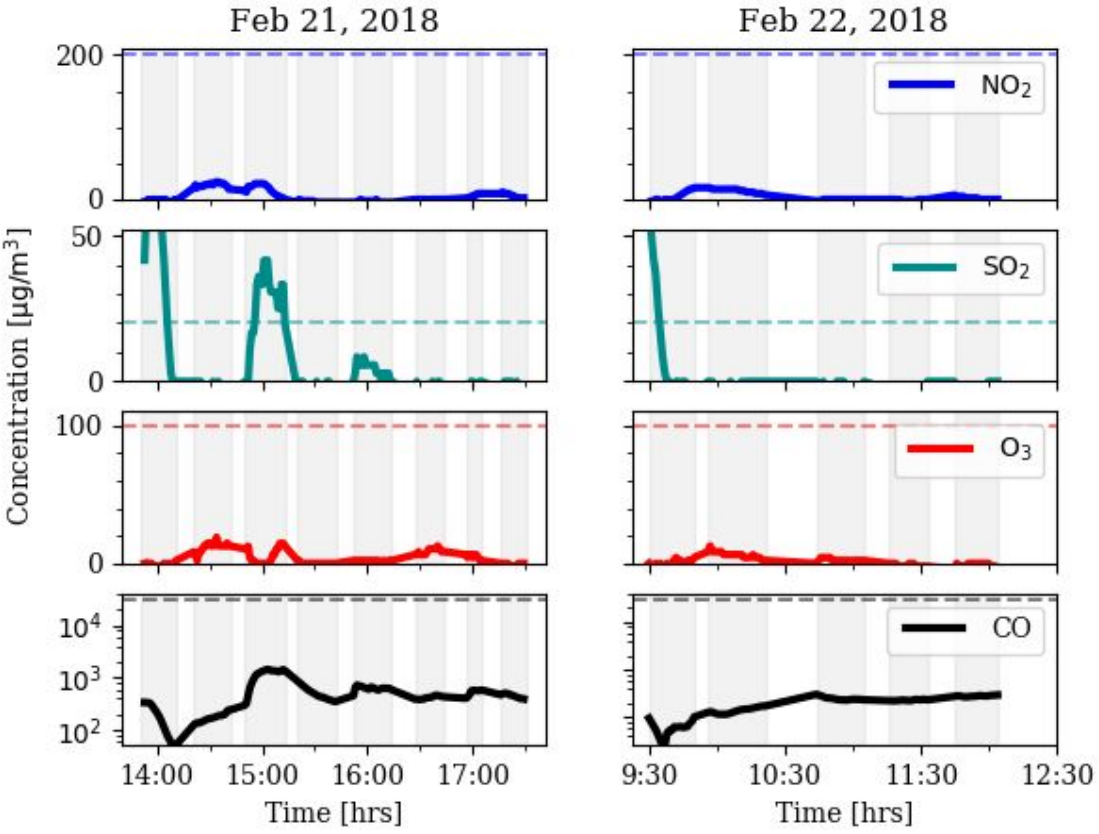
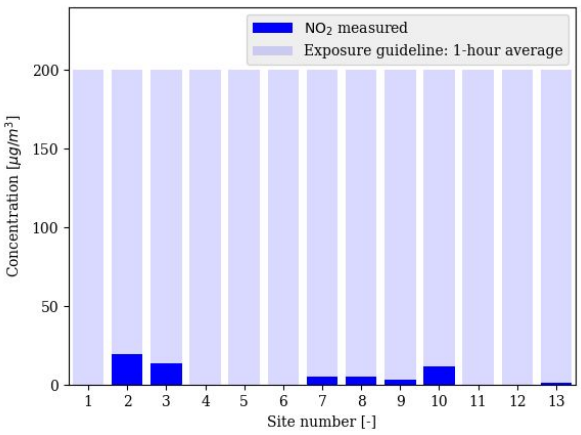
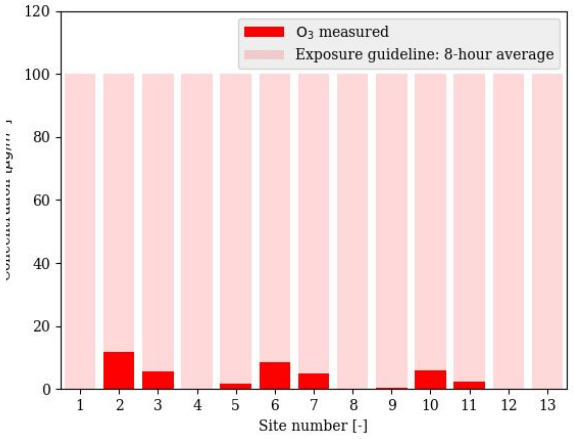


Figure 1: Variation of gas concentration over time. Vertical shaded bars correspond to time spend at each measurement site (See Table 1). The dashed lines represent the current WHO exposure guidelines values for each gas pollutant. The measured data represent 1-min average values, while

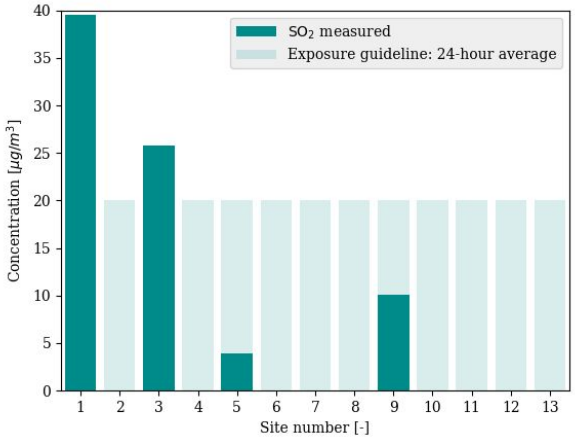
the guidelines are defined for different average time periods. The CO data is plotted on a logarithmic scale to better visualize it.



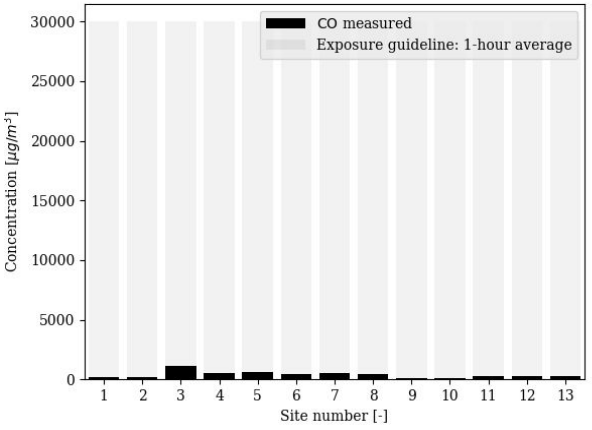
(a) Nitrogen dioxide



(c) Ozone



(b) Sulphur dioxide

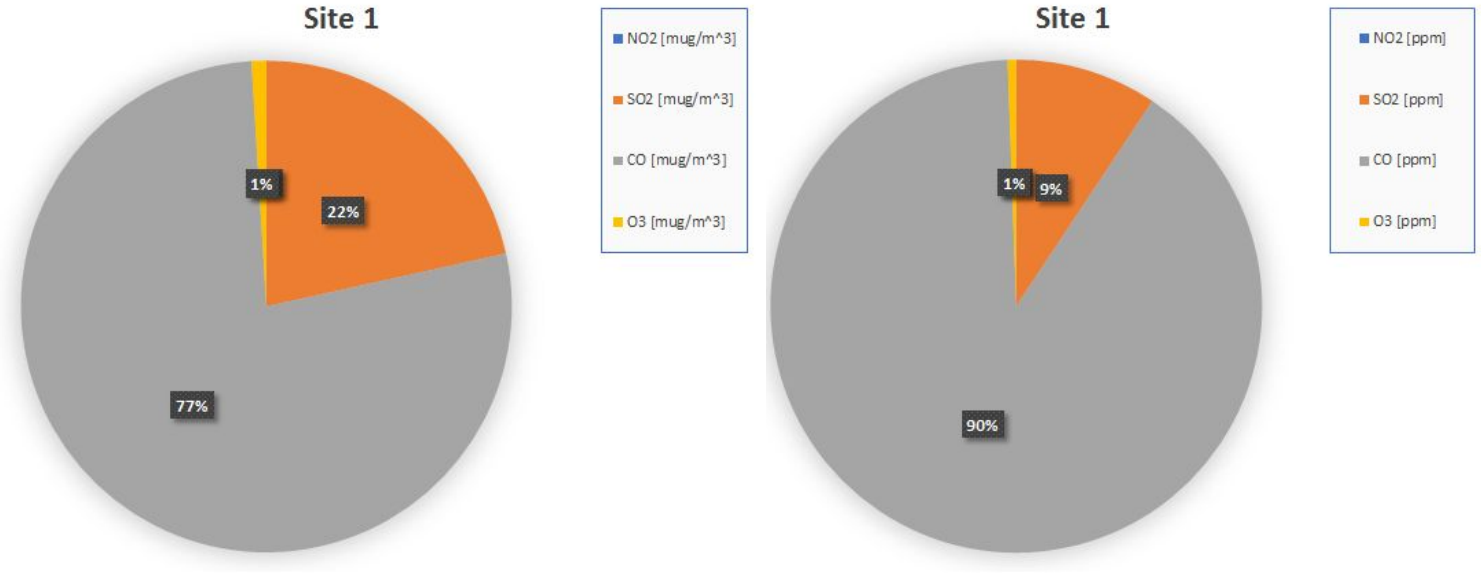


(d) Carbon monoxide

Figure 2: Average gas concentration for each measurement site. The shaded regions represent the average exposure guidelines for each gas pollutant. The guidelines are established for different time periods. The measurements represent an average over 15-20 minutes.

Figure 1-2 shows two different ways of displaying the same measured data. In general, it can be seen that the concentration levels of these pollutants are much lower than the exposure limit recommended by the WHO. These data shows that the air quality in Eindhoven is adequate; nevertheless, to reach a definite and a reliable conclusion, more measurements have to be taken. More data will help determine if the atmospheric temperature, the seasons, the rush-hour traffic hours, the particular location, etc. have a relevant impact on the local air quality.

Another alternative to study the data, is to visualize the gas ratio in a particular measuring site as shown in Figure 3. In this particular case, the choice of a specific unit can influence the perception of the measurement results for non-experts and provide a plot which could be misleading or misinterpreted. Gases have different molecular weight, therefore concentration of pollutants by weight ($\mu g/m^3$) varies from the concentration of pollutants by number of molecules (ppm). For this reason Figure 3a might seem to convey a different information than Figure 3b for the non-experts. These figures highlight one of the challenges faced when scientific results are communicated to the general public.



(a) (b)

Figure 3: Percentages of pollutant present at the first measurement site in (a) $\mu g/m^3$ and (b) ppm (parts per million) .

From Figures 1, 2 and 3 the following can be concluded about the Eindhoven air quality in February:

- The CO concentration levels seem to be higher during the afternoon hours (i.e. measurements taken during the first day). The other gases do not seem to show such patterns.
- Rush-hour traffic does not seem to have a clear distinguishable effect on air quality.
- SO_2 concentration levels show a peak at the beginning of each day. This might be due to a stabilizing or adaptation time of the measuring equipment.
- The most interesting and insightful measurements are probably the ones from Site 3, which was located at the ventilation exit of an indoor parking lot. SO_2 and CO concentrations are considerable higher than other areas in the city. For a person that only spends a couple of minutes in a parking lot, this level of air pollution most likely will not be critical and will not exceed the guidelines limits. However for someone that works 8 hours a day at such parking lot, his/her exposure to those concentration levels will most likely surpass the guidelines

values.

- The manner in which the data is visualised should be chosen very carefully as it has a significant impact on the overall message the data can convey.

Extra FILTERED Prototypes Drafts

We worked simultaneously in three different scientific articles to produce the first FILTERED prototypes for the website. Those prototype pieces are still a work in progress, they are still not ready to be published on the website, they have not been approved by the scientists.

Blocken et al. (2016) was the scientific paper which we condense and explained in more detail in Part 3 of this Report. But we also worked on two other condensation prototypes drafts:

Schmitz (2005):
https://docs.google.com/document/d/1fQpGVWX1UVJbL3CVI_e2TKxzyLun0MFui9ikuq2SN8I/edit?usp=sharing

Tanio et al. (2016):
https://docs.google.com/document/d/1lZbqAumApMNlgOtWwljUbS2qiLa1xo85eRRmsIG4vmg/edit?usp=sharing

Individual Self-Reflections of Team Members

The following section includes a self-reflection, completed by each member of this research team, in effort to reflect on personal development as it relates to the course's T.I.E.S framework.

Mary

When I signed up for the Urban Air Quality Challenge, it was not clear to me what the course was about, and it did not turn out to be what I was expecting. I had the idea that it was going to be much more technical given Prof. Blocken involvement. However, I was nicely surprised and really enjoyed the course. I learned a lot of concepts/ideas that I didn't even know, I did not know. This course was a sort of "self-discovery" for me because I was challenged to think/act in a way that I do not normally do. It was enriching and exciting.

Nevertheless, since the beginning I had a clear idea of what I wanted to get from the course. For scientific curiosity, I aspire to simulate the air pollution in the atmosphere in the near future (T: Technology).I wanted to use the Urban Air Quality Project as a starting point to build towards that goal (E: Experience). I wanted to understand:

1) how can I appropriately convey the scientific findings to the general public? (I: Innovation, S: Shift skills)
2) who will be interested in those kinds of studies? (i.e. governments, academic communities, etc.) (S: Shift skills)
3) how can I get funding or who will be interested to pay for this kind of simulations? (E: Experience, S: Shift skills)

Because of time limitation and the diverse background of the team members, our project does not directly involve the simulation of pollutants as I was originally hoping. However, the team project does picks up on the same questions that I wanted to answer from the beginning: 1) how to effectively convey scientific findings, 2) how to get the non-experts interested and 3) how to get funding for science communication. I am surprised, but super excited, at how our team project has evolved and I hope we are capable of taking it to the next level and continue developing the science communication platform in the future.

I did not set any goal specifically for each learning outcome, but I did make some progress on each area.

Learning outcome	Achievements
Direct their own development	I am not a “standard student” in any way. But I still decided to sign up for the course to expand my limits. I had the courage to take the challenge which shows that I have a learning mindset. But mostly, I recognize the support and I am extremely grateful for the opportunity; it is wonderful to have a team of professors and academics supporting new and innovative ideas/projects.
Initiate and/or make a change	I was not familiar with a design thinking and innovation processes. Before joining the course, I thought this process had to be just common sense and intuition. I never realize the depth and structure that you should have in a design and innovation project. It was hard to “feel lost” and to learn to have the patience and courage to accept and follow other perspectives that are so different from mine.
Collaborate and communicate	I enjoyed and learned working with my team. It was enriching to collaborate with people from different backgrounds that complement my qualifications. We, as a team, work well together. However, I did struggle when trying to communicate effectively with the other team members. It could have just been the long-distance, or the different language that we use depending on our background, or different expectations, or something else; but I often found that our communication was not ideal. The other team members might not necessarily agree with me. For example, during our discussions, I often felt that the four of us “agreed” on an idea, but our four ideas were completely different. I am not used to working in teams, I felt out of my comfort zone. I have contributed to many good ideas and provided different perspectives to our discussions, but I need to work on how to express my ideas and encourage people to listen to me more carefully, as well as to build patience and tolerance when communicating with people that do not think like me. An irony concerning the topic of our team project.
Understand and apply game-changing technologies	Because of my science background, I was able to contribute with the interpretation of data and the analysis of statistics. However, I know I do lack a lot of understanding when it comes to air pollution. There is so much to be learned. I enjoyed the scientific talks we had during the course.
Plan, conduct and evaluate a research/design project	I consistently helped frame and reframe our team project, giving different perspectives, constantly questioning statements, as well as accepting that I need to continue learning in areas where I have no experience. Being a scientist, I also know how the scientific community is struggling in order to communicate to the general public and make itself be heard.
Build, actively participate in and maintain a network	Our team project indirectly gives us an opportunity to collaborate with experts and institutions; engaged in building, actively participating and maintaining a network.

With our team's intensive discussions, each particular team member's expertise and, in my case, my experience as a scientist, we managed to find a small niche of action that nobody has really thought of or acted upon to design our project. I think, we as a team, if we do things right and seize the opportunity we can build a successful project. Our project focuses now on air pollution, but it can be applied to any area of science.

Evan

At the beginning of this year I had just started my master's in mechanical engineering, marking the fact that I was nearing the end of my educational career and approaching a professional career. This notion triggered me to start looking for new ways to challenge and develop myself beyond the mechanical engineering curriculum. I therefore decided to enroll in the honors program to see where I could find such a challenge, which I found in the form of the ACE Urban Air Quality Challenge. I initially joined this project as it was a great opportunity to gain experience in working in an interdisciplinary team with group members from different nationalities. But also, perhaps even more importantly, because I wanted to contribute to a solution for one of the biggest challenges we currently face as a society.

Looking back, both the nature of this project and working in a team with people from such diverse backgrounds, really challenged me to question the way I approach problems as a mechanical engineer. When making a decision, I have been trained to judge alternatives and make a choice in order to progress in a project. In other words, I immediately try to converge on the most suitable solution and fully develop and implement it. However, already during the first site visit it became apparent that this strategy simply was not going to work on a problem of this magnitude. In brainstorming with my team and talking to the project coaches, I developed a better understanding of the mindset needed when designing for innovation.

When we arrived in Toronto for our second site visit, we thought we had a pretty solid idea, at least from a technical point of view. However, during this week I was introduced to a variety of methods which force you to take a look at your idea from a multitude of angles. In using these tools, we quickly realised that our solution did not quite 'cover all the bases' and needed some serious changes. While this was a bit discouraging at first, it taught me that not knowing it all is not a bad thing. Knowing what it is that you do not know, gives direction for research and helps you redefine your design and problem statement. This realisation motivated me going forward and it took away part of the uncertainty that accompanied our project. In the end, we came up with a new concept that we all feel confident about and ha

To conclude, joining this project made me realise what I can achieve by changing my mindset. Joining this project led to me meeting all the people involved in the ACE challenge, being introduced to new concepts and ideas and travelling to Canada. I experienced what it is like to work in an interdisciplinary team, on a project with the intention of serving a higher purpose. Going forward, I wanted to keep looking for new challenges and continue working on projects of this nature. This resulted in me joining Solar Team Eindhoven where I will be in charge of supplying a team of

twenty-six students with everything they need to build a solar powered family car. As of yet, I can only speculate where this decision will take me. It will undoubtedly be difficult at times, but I am confident that it is also going to be a once in a lifetime experience which will provide me with new insights and lessons learned.

Learning outcome	Achievements
Direct their own development	I started this project with the goal of being put in new situations, with new people and new concepts, in order to develop myself beyond what I am taught in my regular university courses. For me this project was an opportunity to learn from people from different backgrounds and I believe I was successful in doing so.
Initiate and/or make a change	After the first site visit, our team's progression was falling behind. We met once a week as a team, but there is only so much we could achieve during one meeting. I therefore proposed another weekly meeting to Priyanka, so that we could use the fact that we were living near each other to sit together in real life. Both of us gained a lot of new insights and we came up with a number of ideas.
Collaborate and communicate	Again, my goal was to learn from the different perspectives in our team. I was very pleased about the manner in which our team collaborated during the site visits and the progress we made during our real life meetings. There was a healthy balance between sticking to one's point and seeing the other's point of view and adjusting yours accordingly. However, collaborating during our weekly skype meetings proved to be challenging right from the start. We developed a few systems to keep track of what was said and task division by keeping online meeting minutes from every meeting. Looking back we might have also benefited from assigning weekly/monthly roles (chairman, minute maker etc.) to further smoothen the weekly meetings.
Understand and apply game-changing technologies	I wanted to learn about technologies related to air pollution and I contributed to a large portion of our initial idea concerning the air quality sensors in the public transportation network.
Plan, conduct and evaluate a research/design project	As previously stated, my aim was to learn how to approach a problem from a perspective other than a mechanical engineering one. This was not an easy task but throughout the project I have used the tools provided to me as well as build my knowledge from that of my coaches, teammates.

Build, actively participate in and maintain a network	I used every opportunity I had to pose questions to my teammates, coaches and experts. In retrospect, I could have made use of this network more extensively outside of the site visits. For instance, our team did not ask for feedback from the OCAD coaches, which would have been useful.

Priyanka

My involvement in this project was purely based out on my interest in the topic. I applied for this course when I came across the flyer put by Prof. Bert Blocken and honestly, I had no idea on what to expect from the course. I knew for a fact that I loved the topic since for the past many years I have been working for various organizations which focused on environmental, human and animal right protection.

As the course progressed I was pleasantly surprised along each point in the journey, as it involved me interacting with a set of multicultural and multi-disciplinary group of people, talking to experts in various fields, interacting with politicians, validating ideas and conducting surveys. This course required me to push my limits and involve in activities I have never done for any other course before. Along the first weeks of this project, I realized that this is a platform, if exploited, can help me learn and develop in many ways.

I did not have clear goals set up before the course as this was completely new for me. However, along the way I realized and learned numerous things and made progress in almost every specified domain.

Direct their own development: It was my passionate desire to make a change even in the smallest way possible that attracted me to this course. I wanted to do it with an equally like-minded team and this project was the perfect opportunity. Being a technical student, I was aware of the various scientific facts surrounding air pollution, but however I wanted to investigate the other dimensions of it. So, by doing a comprehensive literature review of India and China I was also able to explore the political and social side of the issue. Having other nationalities was an amazing opportunity for me to learn more about Chile, Mexico and Netherlands.

Initiate and/or make a change: This was one of the most challenging part for me since I have no prior knowledge or experience in this area. What I learnt is that, it is a good idea to analyze the situation from a broader point of view other than relating it back to the problem statement. This is a good learning curve, as even if our ideas aren't great, there is a lot of things to be learnt in the process. However, tools like business model canvas and value proposition canvas explained during Toronto site visit have been great assets, but I personally believe that it should have been explained during the first site visit.

Collaborate and communicate in a multidisciplinary team: Since Evan and I were from TU/e, it was convenient for us to collaborate over the week and discuss our progress with the rest of the team during Skype calls. However, on some occasions Mary and Kate found it difficult to be on same page

as us, as transferring ideas over a call proved to be really challenging. In spite of this, it was great to have four different nationalities and disciplines working together in this project. I learned a lot along the way about how a design student would like to represent ideas and views on how a scientist like Mary would like to have her views presented.

Understand and apply game-changing technologies: With my technical background, I really enjoyed learning about air pollution from a scientific viewpoint. The sessions by Bert Blocken on general aspects of air pollution and wind tunnel experiment were highly interesting. I also got some amazing insights during the visit to University of Toronto where they exhibited the different sensors and measurement devices for monitoring and controlling air pollution. The project also challenged me to go way beyond my technical knowledge in my domain of electronics. I enjoyed and learned various aspects of computer science while trying to develop our prototype. It was however unfortunate that we could not take the measurements in Toronto because the results we got from Eindhoven were quite interesting to analyze.

Plan, conduct or evaluate a research/design project: Along the way, our research question was modified several times as the problem we are trying to tackle became clearer. Talking to various politicians and experts involved in the field, I realized the importance of validation. We had come up with ideas which seemed like brilliant propositions from our point of view, however after validation I realized that we were coming up with solutions for aspects that were either not problematic or were non- existential. This was evident when we came up with our initial idea on having sensors installed in buses. I learnt that the correct approach was to look at the technical feasibility and the other aspects only after validating the idea.

Build, actively participate in and maintain the network: I realized the importance of talking to experts after validating our initial sensor idea with a politician in Eindhoven. Even though the literature review showed the lack of data as the problem in India and China, expert opinion showed otherwise. Our current idea was mostly framed on the basis of the talk we had with experts in Canada where we saw that there is an enormous amount of data put there, but the challenge is to get this data out to the public.

This was a pilot course and there were some things which could have been different. But in spite of that, being a course totally different from my regular subjects, I learned some great and wonderful things in this period of six months. I developed skills which I never would have and learned courses which I will be passionate for life. It gave me the confidence and motivation to take up more projects in this domain.

Kate

I embarked on this course eager to work with peers outside of my field and expertise. With little to no technical skills/background it was an intimidating prospect but one that I was eager to experience. Working through the challenges we experienced as a multidisciplinary team was one of the most rewarding parts of this pilot course. Along with, of course, the relationships we had the opportunity to build with one another and also importantly with the content. Air quality was a topic I new little about at the onset of this course, another factor that contributed to the intimidation of this project's proposal. However, I will now never be able to turn a blind eye to the mounting

challenges this problem presents our global community with.

While this experience was filled with a series of high ***yes*** moments but also of low ***no*** moments our work, in the end, speaks for itself and is stronger because of the challenges we presented each other with and the openness everyone on the team brought with them to alternative ways of problem solving and approaching urban air quality. This course validated a large amount of the skills that I have developed through my masters course at OCAD University. It also forced me to consider the large importance that exists in one's own ability to share and bring people into their own process. Despite the time and effort it takes to find a common language it is vital to collaboration but also because it is so time consuming can often be disregarded at the detriment of the projects final outputs.

Learning outcome	Achievements
Direct their own development	As I mentioned, signing up for this course involved several different levels of risk and demanded oneself be okay with being uncomfortable. This I welcomed with open arms and was excited to push myself to become a better designer, collaborator and facilitator through this process. I think the biggest personal development was with regard to challenging myself to more empathetic and clear about why I suggest certain working methods or process and the value that they hold to the team and our final product. I have learned a great deal about how to approach multidisciplinary teams because of the development I underwent during this course.
Initiate and/or make a change	I was probably the one team member most comfortable with this learning objective and enjoyed being able to really test the methods and approaches I have been learning through my work at OCAD in a team setting very different than the teams we are used to working with. Asking my team to trust and partake in the design and innovation process was not always easy but, to reiterate, was a valuable lesson and outcome I received from this course.
Collaborate and communicate	I think collaborating and communicating is a learning outcome that exists as a part of all the other learning outcomes listed herein. Collaborating and communicating were the two areas towards the end of this project that our team really struggled with. Time constraints had stretched so many of us so thin that we were not able to devote the mental energy required or the time required to successfully collaborate and communicate remotely. Evan and Priyanka, in deciding to meet together without the other half of the group on a weekly basis set in motion a divide in the group. Mary and I no longer felt like decisions were being made in the manner in which we had discussed in the team contract. Evan and Priyanka moved the project forward in directions without Mary and I's involvement and left us in the dark for the most part on the work they were doing in Eindhoven. Several attempts were made to course correct the rift that continued to grow larger with little success. This impacted the productiveness of our weekly meetings as a team because we spent most of the hour to two hour long meetings catching up to speed on developments that had been made in the project earlier and discussing those instead of being able to use the time together to make

	collective decisions and advance the project toward a unified vision.
Understand and apply game-changing technologies	Because of my limited technical background, understanding and applying game-changing technologies was probably my weakest learning outcome. The solution our team produced was not as technical as some of the other groups and so we weren't able to explore technology in the way I believe some of the mentors in this course had hoped we would. However, I do think I learned how to consider the discipline and field of technology as a crucial component of a team to solve most any challenge and will, moving forward, look to engage with and understand more of game-changing technologies as a means of strengthening future projects.
Plan, conduct and evaluate a research/design project	As the team member with the most experience in executing design research projects I learned so much about the things that do and don't work when it comes to executing this type of project with team members who are new to design research. The planning, conducting and evaluating phases must adapt to the different levels of knowledge that exist in a team and understanding successful methods to do this is extremely important.
Build, actively participate in and maintain a network	As a team we are strongly positioned to take advantage of the network that this course has offered and have been strategizing throughout the duration of this project on how best to continue to build upon and maintain the network we have built. We are fully aware of the opportunity this course has given us and I think as a team we've done our best to capitalize on the available network. Individually I am thrilled to have worked on my first project with engineers and hope to continue to foster the network I have started to build from this project.