https://youtu.be/fniXF4Ug7Ys

ADVANCED INTERFACE PROTOTYPING
INFO30005, SEM1 2023

GROUP 4

# FOOTPRINTS

## A NOVEL INTERACTION PROTOTYPE REPORT


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Video Component Link:

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Melbourne is a fantastic city full of attractions, natural parks and a near-infinite amount of places to get a coffee. But, people are having trouble finding the motivation to get out and explore the city...

# Contents

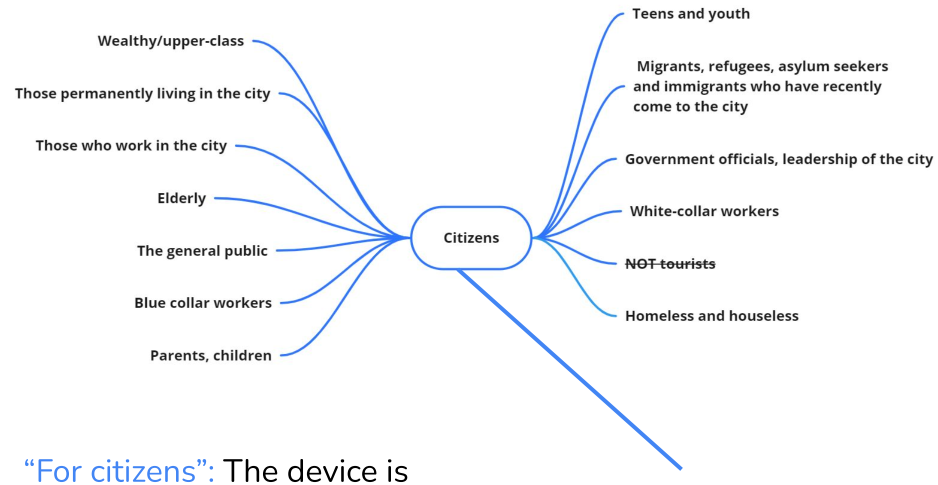


# Introduction to the Brief

Today, cities around the world are under pressure from continually increasing populations and mass migration from rural to urban centres. This has led to a number of factors that have deteriorated the quality of life for urban citizens, particularly the ease and pleasure of mobility in the wake of congested and polluted city streets. In an effort to reduce these effects, cities are increasingly striving to transform themselves and become 'smart cities' - cities that are "more sustainable, liveable and efficient" (Joshi et al., 2016, p. 903).

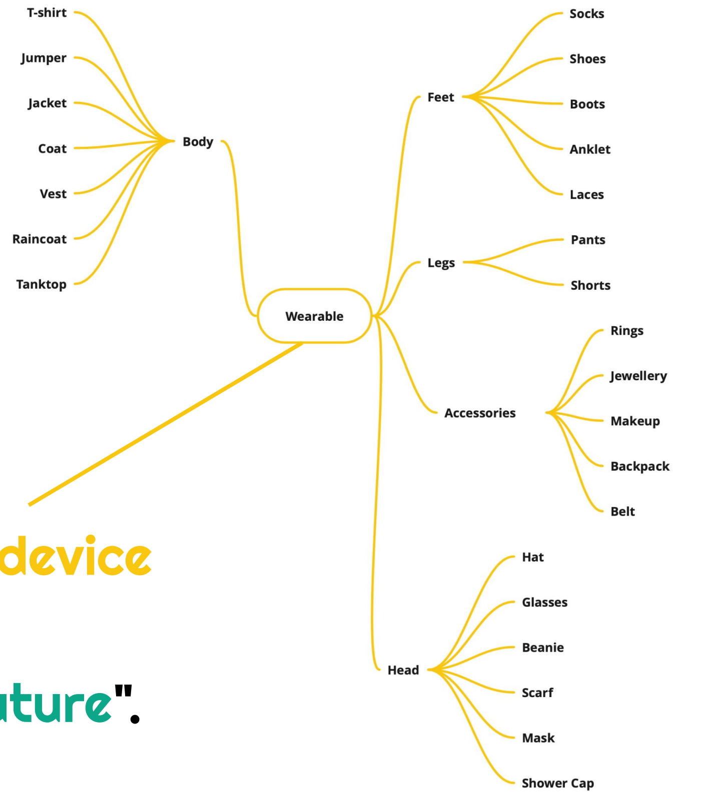
As part of their strategy for Melbourne to become a smart city, the City of Melbourne has created a brief for the conceptual design of a new device which is to be **"a novel interactive wearable device for citizens to interact with a smart city to enable a sustainable future"**. Additionally, the City of Melbourne has provided access to a range of city data APIs. These will enable the device to integrate real-time data in its operation enabling it to increase its effectiveness and performance while in usage. Given the broad nature of the brief, we have interpreted its meaning in the following ways:

# Introduction to the Brief



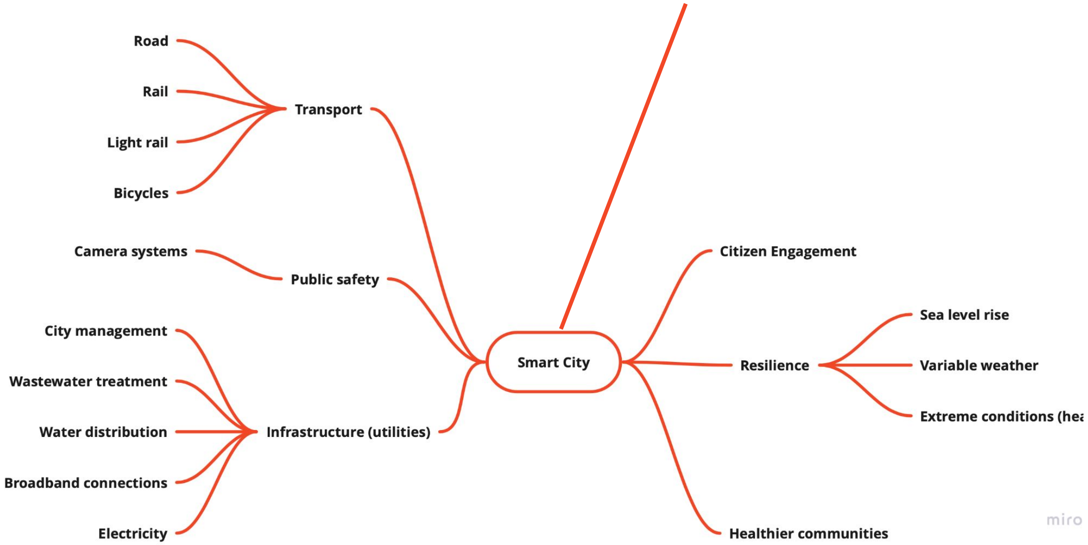

"Wearable": The device should comfortably fit on the body whilst the user is moving and be easily adjustable for different body dimensions.

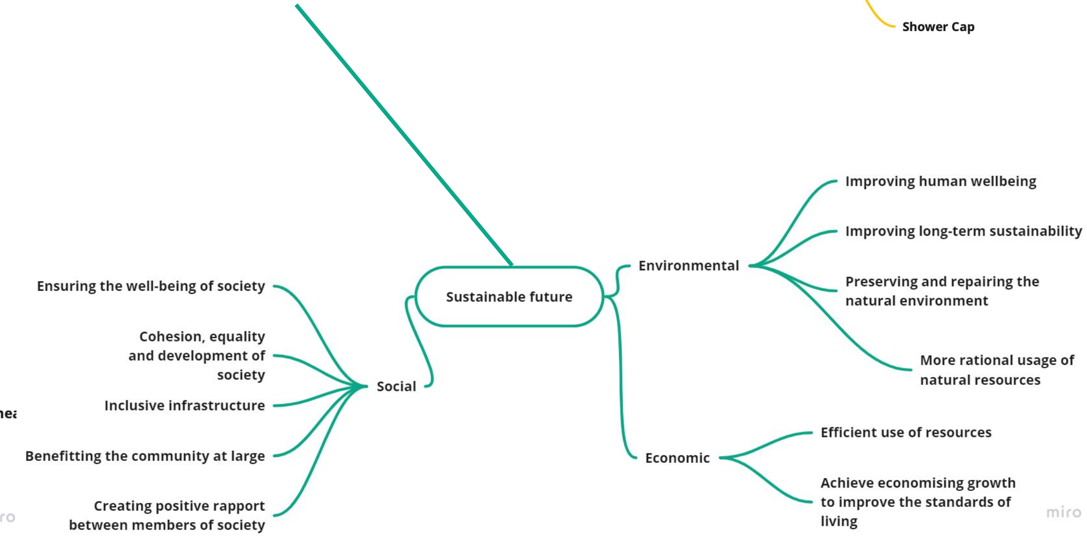
"Interactive": The user must be able to provide an input command in order to be supplied with some type of output.




"For citizens": The device is relevant and appropriate in most situations for all people within a city.

**"Design a novel interactive wearable device for citizens to interact with a smart city to enable a sustainable future".**



## ...to enable a sustainable future.

- The device promotes a future which addresses key social, economic and environmental concerns.
- These concerns are largely captured within the Sustainable Development Goals (SDGs) proposed by the United Nations (UN) (2022). Out of the 17 goals, 5 have been selected to be our focus areas for this project. These are:

# Problem Motivations

To begin forming a solution that meets the brief, we must obtain an understanding of what problems Melbourne and its citizens face. Considering the 5 SDGs chosen for our project, we identified two key problem areas:

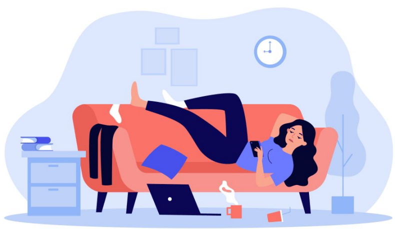
Health

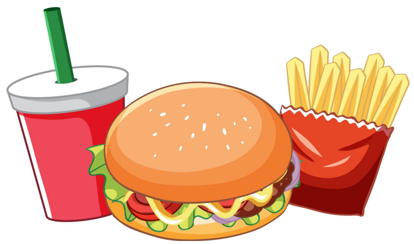
Environment

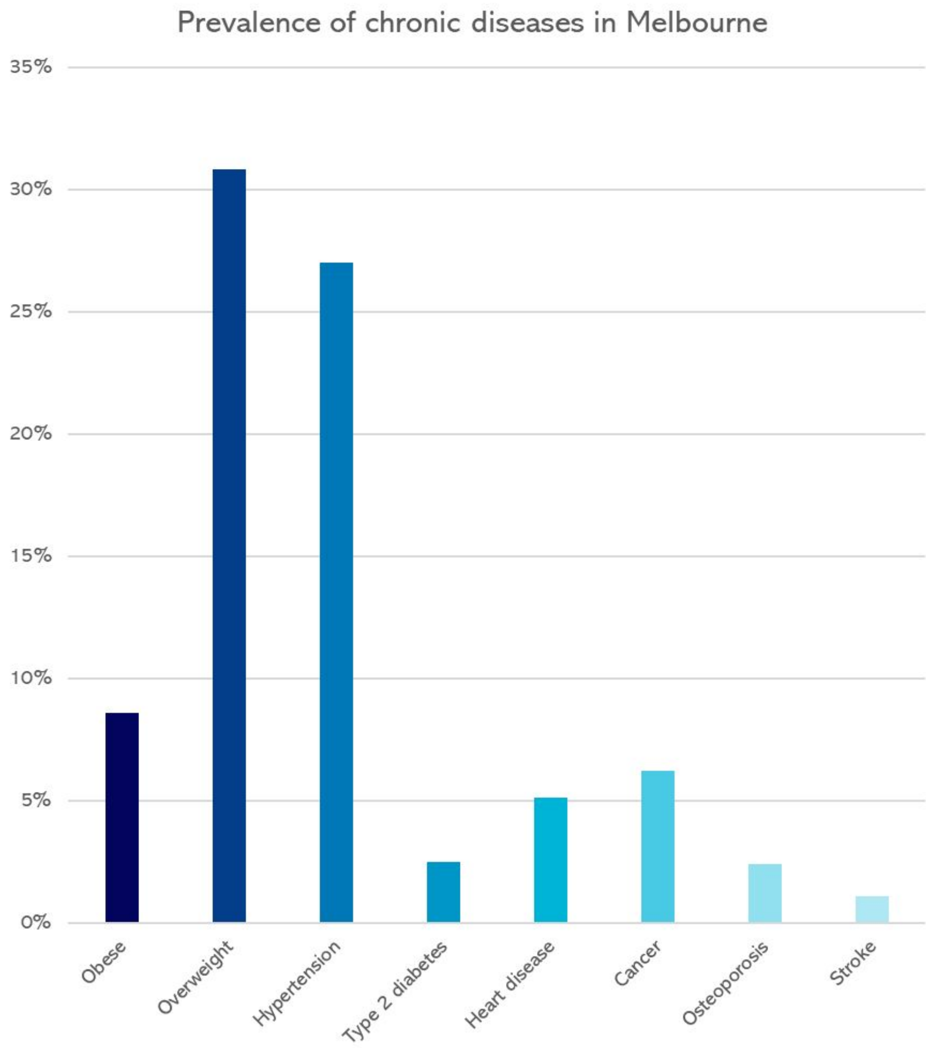
# Problem Motivations

## Health

Melbourne has a health crisis. Like the rest of Australia, the city's leading cause of death are chronic diseases that give rise to almost 9 in every 10 deaths (City of Melbourne, 2020). Today, these diseases such as diabetes, cancer and heart disease are decreasingly attributed to congenital disorders and instead an increasing proportion originate from health-risky behaviours, particularly physical inactivity and unhealthy diets (Australian Institute of Health and Welfare, 2017; Victorian Health Promotion Foundation, 2016). Considering these diseases are highly prevalent and a significant harm to health, an urgent remedy is needed for this crisis.



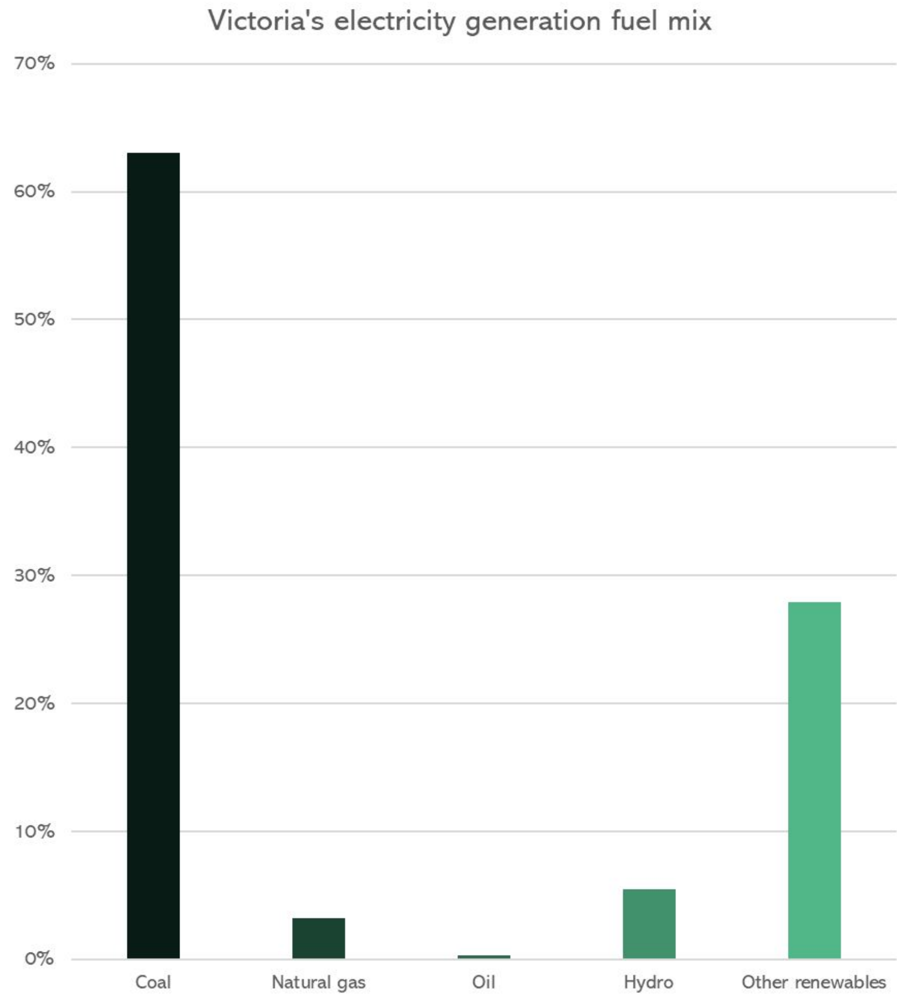





*Note.* Based on 2017 data obtained from City of Melbourne (2020).

# Environment

Similarly, Melbourne has an environmental crisis and ranks amongst the highest carbon dioxide emitting cities in the world, polluting the atmosphere with approximately 4.7 million tonnes of CO2 equivalent annually (City of Melbourne, 2018). Largely, this is due to the fact that the Victorian capital continues to rely on fossil fuels to power its urban streets. When divided by sector, it was revealed that some of the largest contributors to emissions were commercial buildings (60%) and private transport (9%) (City of Melbourne, 2018). Melbourne needs to transition to more renewable sources of energy to power its buildings, infrastructure and transportation.




*Note*. Based on 2021 data obtained from Department of Climate Change, Energy, the Environment and Water (2022).

# Current Approaches for Addressing the Problem

Following the key problem areas and their root causes identified in our research, we chose next to focus on the approaches Melbourne is currently utilising in an attempt to address these issues. By exploring the existing solution space, it is likely new opportunities for innovation can be discovered. Specifically, we aim to understand:

**What kinds of activities are being encouraged in the city?**

**What kinds of activities are being discouraged in the city?**

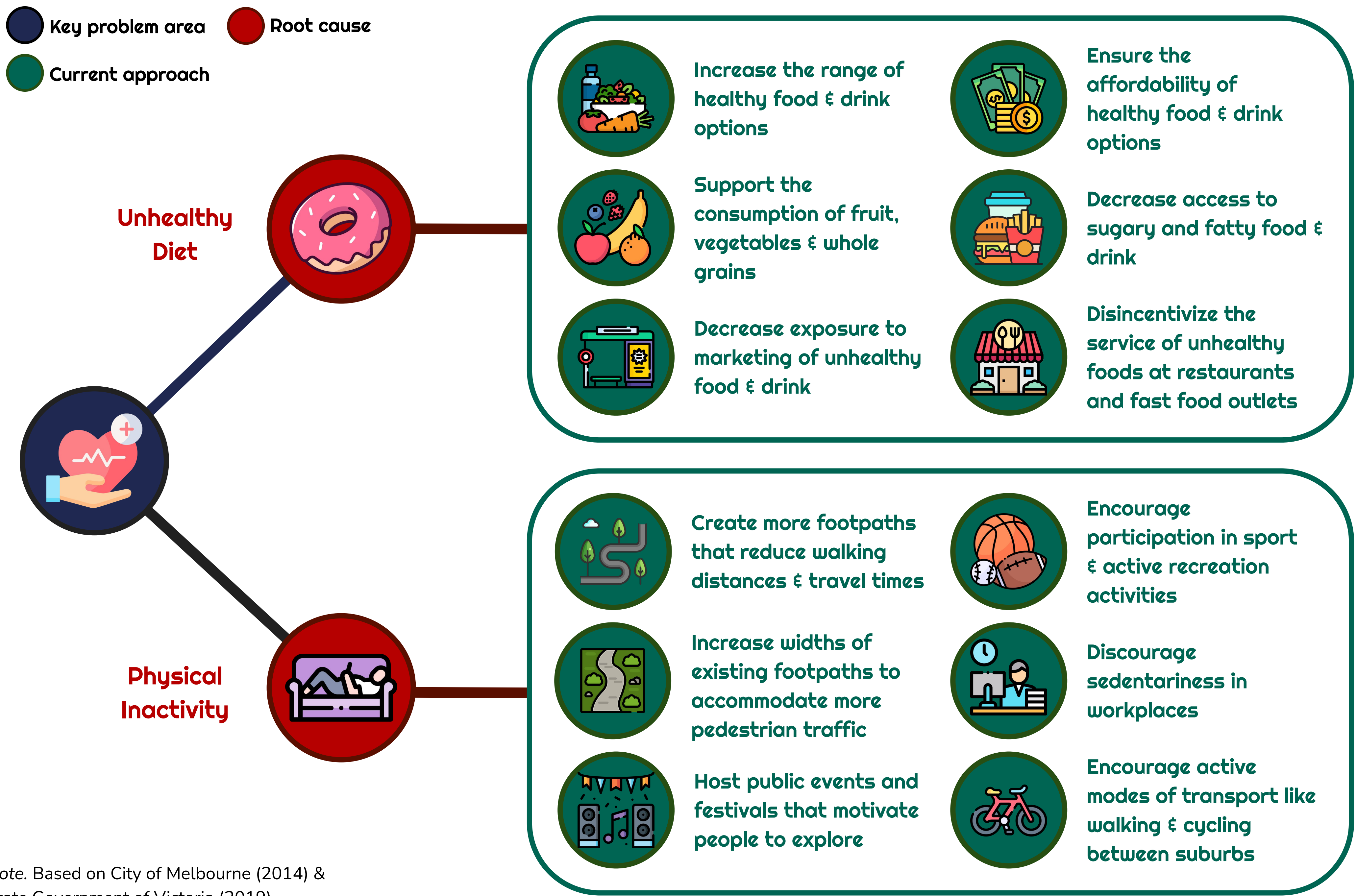
**What factors ameliorate underlying root causes?**

**What factors worsen underlying root causes?**

**How effectively do the current approaches address the issues?**

**Are there any issues that have not been adequately addressed?**

# Current Approaches for Addressing the Problem




*Note*. Based on City of Melbourne (2014) & State Government of Victoria (2019).

# Current Approaches for Addressing the Problem

## What is effective?

Melbourne is actively striving to improve the health of its citizens. The city's efforts to address unhealthy diets are particularly comprehensive where the approaches examined demonstrate a willingness to cooperate with businesses in different industries and at multiple stages of the supply chain. Through the various economic and legal controls being implemented, Melbourne is likely able to facilitate the transition away from unhealthy consumption patterns without any additional support.

## What could be improved?

Regarding physical inactivity, most approaches are from a top-down perspective that try to tackle the root cause by focusing on how Melbourne can change or what citizens can further do in their lives to become healthier. While somewhat effective, the city has overlooked that many people are motivated to exercise within stimulating urban environments (Hillnhütter, 2021) and are potentially unaware these types of environments exist. If citizens were better equipped to navigate the urban landscape on new routes to never-before-seen parks and immersive public events, then perhaps Melburnians would be better encouraged to partake in physical activity.

# Current Approaches for Addressing the Problem

- Key problem area
- Root cause
- Current approach

## Commercial Buildings

- Increase the uptake of solar panels on building rooftops
- Approve building construction based on energy efficiency benchmarks
- Incentivise the purchase of electricity from renewable energy providers
- Promote circular economy principles to reduce embodied emissions in buildings
- Convert existing heating & cooking appliances from gas to electric supply
- Reduce the wastage of electricity in buildings from lighting & appliances

## Private Transport

- Increase the number of public transport services for efficiency
- Reallocate road space to support active transport modes like walking & cycling
- Enlarge the service area of public transport for accessibility
- Increase the presence of security on public transport services
- Encourage the uptake of electric powered vehicles
- Implement traffic light priorities that favour public & active transport

*Note*. Based on City of Melbourne (2018) & State Government of Victoria (2019).

# Current Approaches for Addressing the Problem

## What is effective?

Melbourne is also actively striving to reduce the impact it has on the environment. This is evident by the incentive programs established to increase the consumption of energy from renewable sources and by the implementation of eco-conscious regulatory frameworks for existing and new buildings. Likewise, with upgrades to the public transport system, to accommodate more safe and efficient travel, the city is positioning itself to attempt to sustainably cope with an expanding population.

## What could be improved?

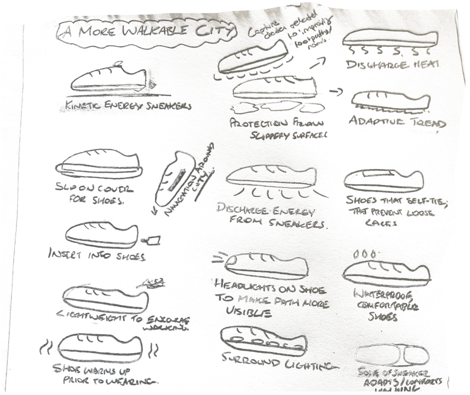
Furthermore, to power a modern city of 5.8 million people (Woodyatt, 2023), a lot of electricity is required. Whilst the renewable energy and energy consumption reduction programs outlined do lessen the environmental impact, many of them are unlikely to be fully implemented within the next decade, resulting in a continual reliance on fossil fuels for power. Given Melbourne's enormous population, we were inspired with the idea of how each citizen could contribute to overcoming this challenge and for it to be achievable in the near future.

After a critical analysis of the current approaches, we see the opportunity to solve for an unrealised problem:

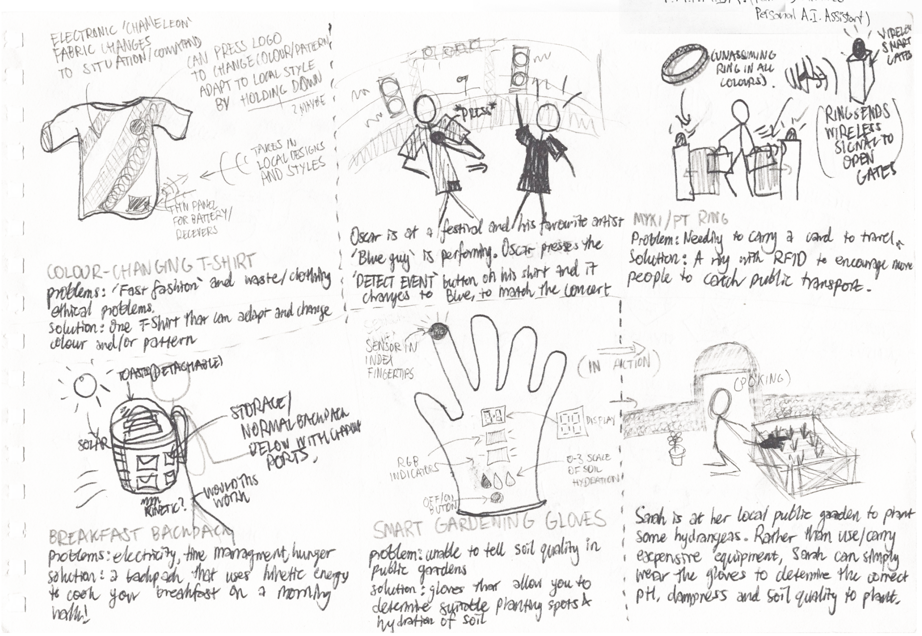
# HOW MIGHT WE...

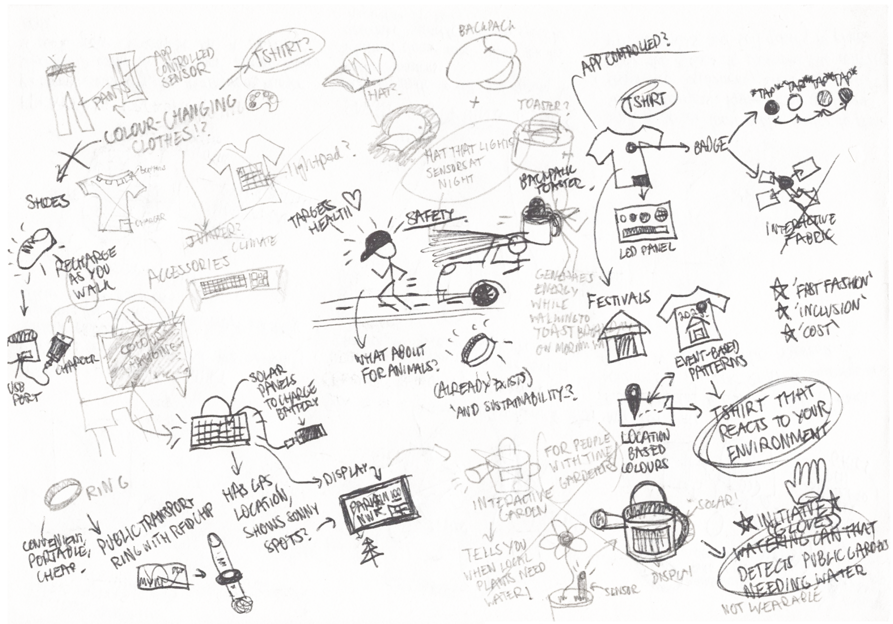
design a wearable device that encourages physical movement and converts it into energy to make Melbourne a **healthier and more eco-friendly** smart city?

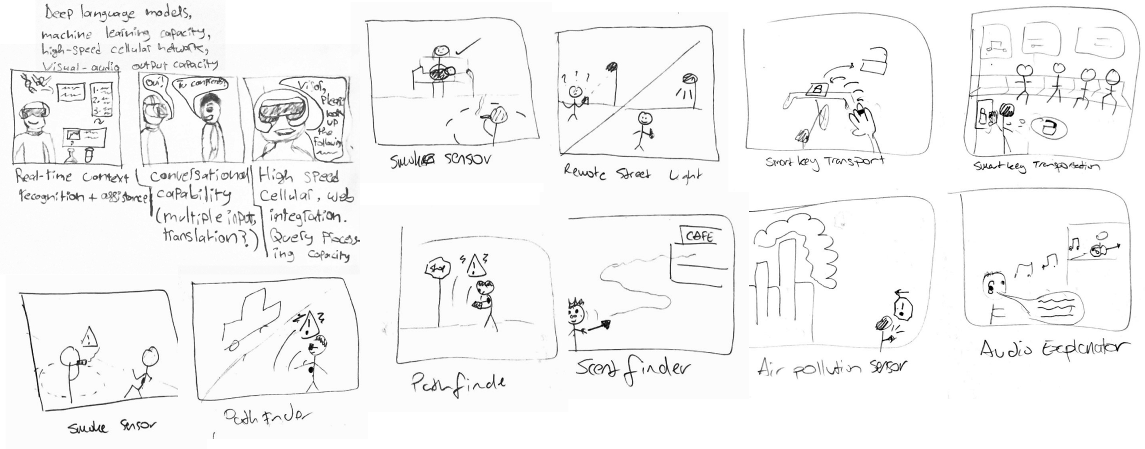
We began the design process by creating a large quantity of rough, low-fidelity ideas that may solve our problem statement.







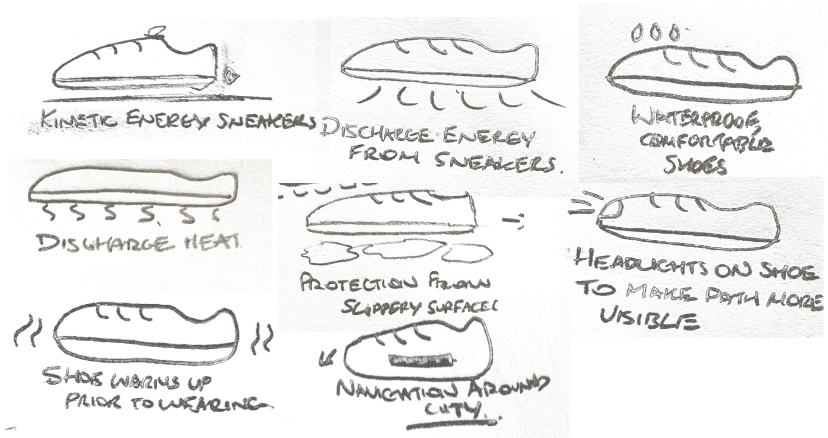



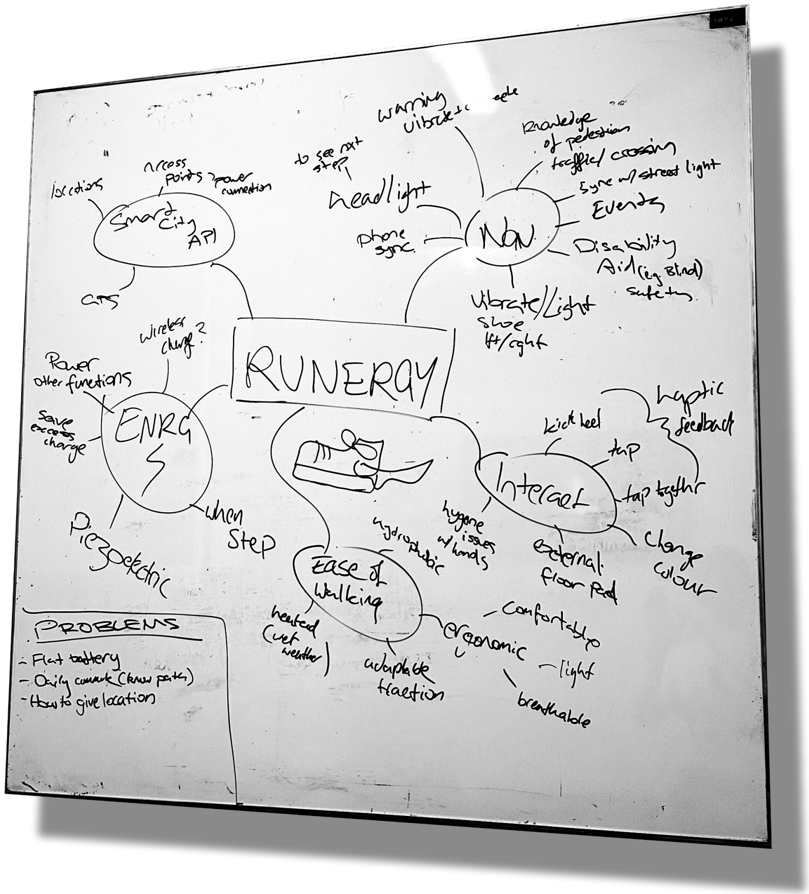




Many of these had recurring ideas, or ideas that we found novel and intriguing.

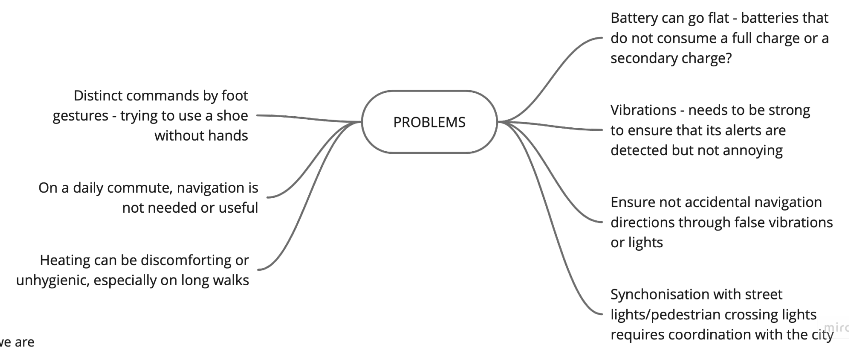
# Initial Stages of Design Process

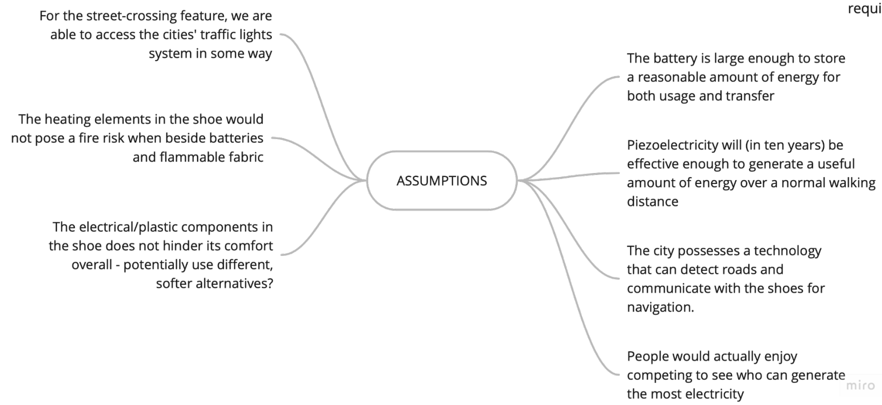
After filtering the ideas based on practicality and usefulness, we settled on one particular idea: an electricity-generating shoe. Shoes are necessary to traverse the built environment and have extraordinary potential to harness the energy generated whilst moving around. If we could produce a new type of shoe that was a source of sustainable energy, but that also incentivised physical activity, it would provide Melbourne with a device to address its current health and environmental crises. We explored how this could be possible through a in-person brainstorming session:




We also determined the major problems and assumptions our rough ideas would have, to see if we could counter them:

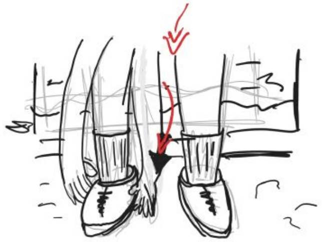


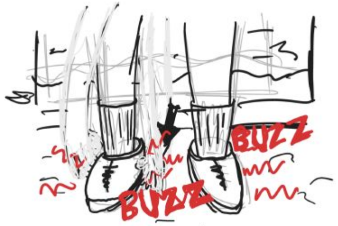
# Initial Stages of Design Process

We then developed storyboards to identify the feasibility of the concept's use in real-life...

*Bob is waking up in the morning and rolls out of bed.*



*Bob rolls into frame and slides into his shoes, tying up the laces.*

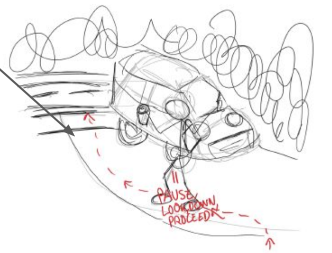



*The shoes buzz in a silence/music pause.*

*Bob walks out his house's front door, coffee in hand and a backpack, toward the car with his keys.*

INCENTIVISING HEALTH & FITNESS

SUSTAINABLE ENERGY GENERATION



*Bob pauses, looks down at his shoes (insert shot of PiezoShoes), puts his keys away and walks instead.*

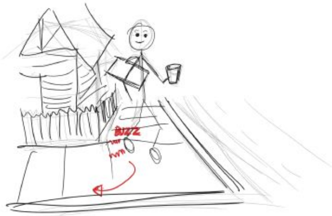
*Bob is walking along the footpath, looking very active (establishing shot).*

*The camera zooms into the shoes, slows time down, shows the shoe charging as identified by the LED charged bar.*

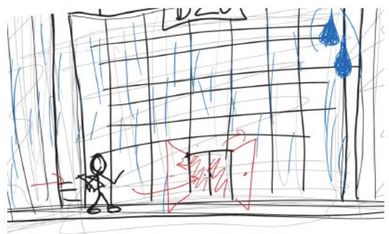
*Bob reaches the corner and looks both ways as if confused where to go, a buzz is heard on the side of his left shoe, as he's turning left.*

NAVIGATION & SAFETY

*This was detected by the 'Smart Navigation' system the city has implemented, which communicates with the shoe to tell it which way to go.*



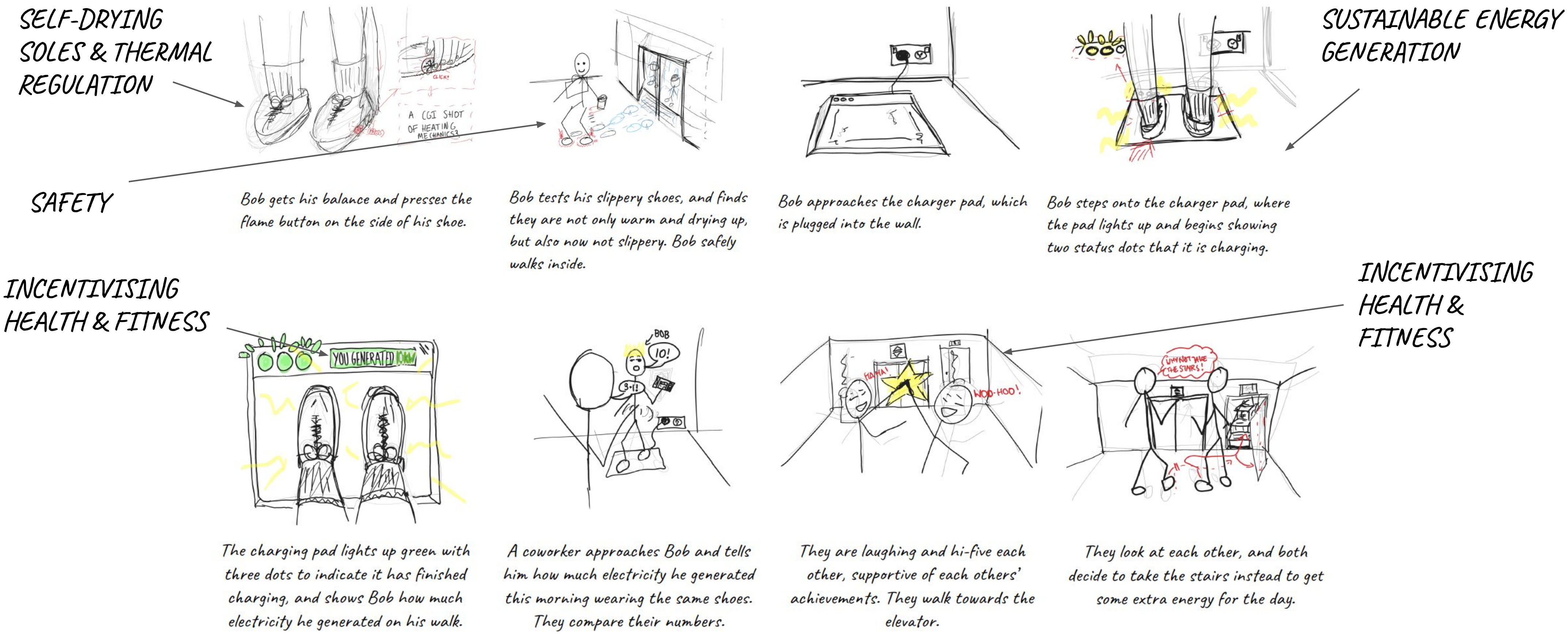
*Bob can successfully go the right/fastest way, not having to wrestle with his belongings to pull out his phone or look up directions.*



*Bob has arrived at his workplace, it was raining for the last few hundred steps and he quickly dashes inside*

*Now inside, Bob's wet shoes cause him to slide on the slippery lino floors.*

# Initial Stages of Design Process




These storyboards revealed some issues with our concept that we needed to address with higher-fidelity prototypes, including:

- **How did the shoe know where the user was attempting to navigate to?**
- **Does the shoe maintain a small portion of its charge so that it can still function before the user generates any electricity?**
- **How can we design a comfortable shoe that contains all of these functions?**
- **Are all of the functions brainstormed appropriate to address the key problem areas?**

However, before the next phase of iterating, additional research was required regarding the feasibility of piezoelectricity generation and what currently existed in industry for novel shoe design to ensure our wearable device was both plausible and innovative.

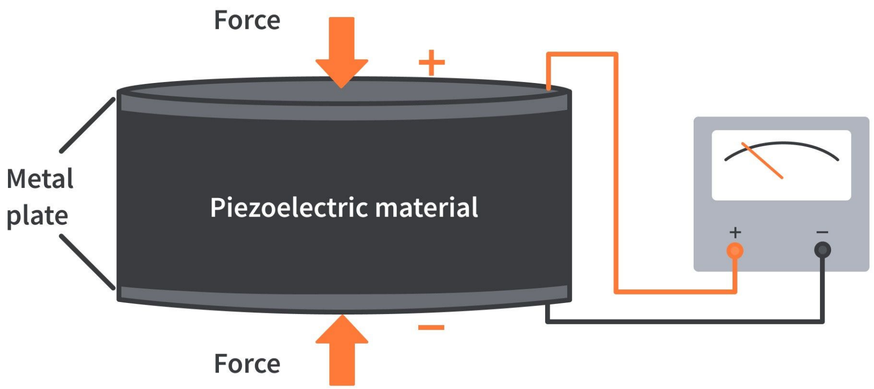
# Reference Projects (Introduction to Piezoelectric Generation)

The use of piezoelectric generators (PEGs) has been effectively documented in a range of applications including cutting edge experimental microcomponents, mid-scale industrial machinery and even household appliances such as gas stoves and bbq lighters (APC International, 2021).

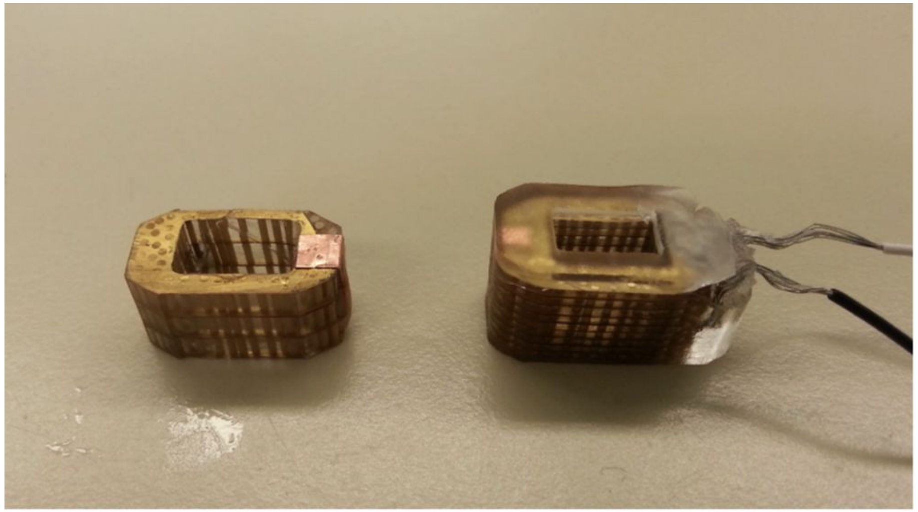
These applications vary in scale and method and can be implemented in different forms and materials such as: single crystals, piezoceramics or material composites such as MacroFiber Composites (MFCs), Polyvinylidene fluoride (PVDF), and Lead zirconate titanate (PZT).

Composite materials often tend to be the best at achieving desirable behaviours depending on the situation due to their high degree of versatility and potential for adaptation to highly specialised use cases.

Each of these material applications can give way to different models of electromechanical phenomena, but they all follow the same basic principles of energy conversion. Which occurs when mechanical stress is applied to a piezoelectric material, causing a change in the atomic structure of the material and inducing electrical polarisation due to the unique properties of piezoelectric materials. Essentially converting the mechanical energy into electrical energy  (ScienceDirect, 2020).




## Stacked MFC Generator for Spinal Fusion Implant



This application featured the manufacturing and implementation of a stacked column 3-layer piezoelectric MFC generator. The purpose of the application was powering a spinal implant without the need for an external battery. This attempted to harvest energy from the mechanical stress produced during natural cyclic loading and unloading of the spine during normal movement.

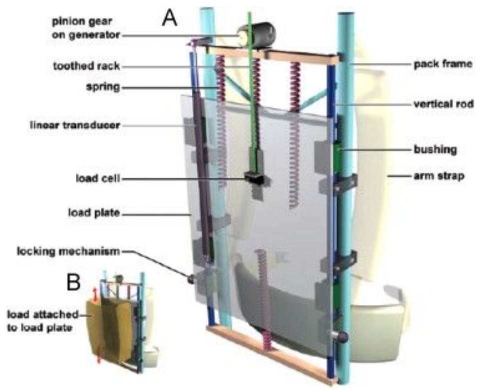
The key findings from this study showed positive power generating capabilities for MFC type generators, but also they showed that encapsulated generators were minimally affected by the encapsulation (A process of shielding the piezoelectric components by covering with some type of epoxy resin).

This shows promise for the practice of protecting some types of piezoceramic materials which have higher power generating capacity but also higher risk of stress fractures.

Note: Source: (Tobaben et al, 2015)

# Reference Projects (Piezoelectric Energy Harvesting)

## Mechanically Amplified Piezoelectric Backpack

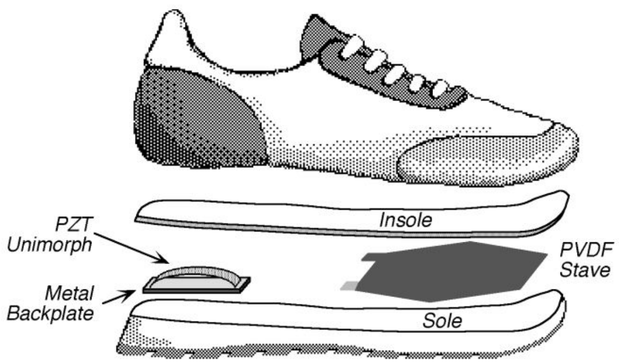



A project that explored potential of harvesting energy from the differential forces produced by moving around with carried loads. This attempted to harness the dynamic tension in the strap as the carrier and the carried load produce opposite movements. The design relies on mechanically amplifying the low forces in the strap in order to produce higher stress tension at the stack actuator.

The resulting power output is reportedly able to "be used to power some small, low power electronics or could be accumulated over the duration of the excursion leading to emergency energy when needed".

Note: Source: (Feenstra et al, 2008)

## Parasitic Power Harvesting in Shoes

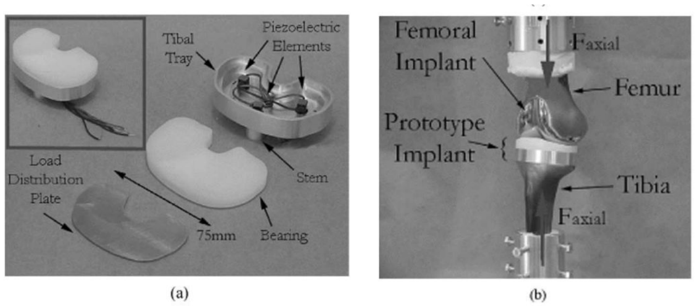



This experimental study explored the idea of parasitically harvesting excess energy while walking to generate electrical power. It tested two different built in configurations: a unimorph PZT strip, and a multilayer PVDF foil.

Findings showed that the reported impact of the components was minimal and did not hinder normal walking when attached directly under the insole. Secondly, the reported energy generating capacity from this application was highly consistent across both configurations. In the case of the PZT strip it is understood that the overall energy generating capacity is limited to supplementary power applications.

Note: Source: (MIT Media Laboratory, 1998)

## PZT Power Generation in Orthopedic Implants




This application embedded PZT materials into orthopaedic implants to harness excess energy produced through normal movement.

A PZT ceramic was placed on the tibial tray which is contacted by a load distribution plate under the bearing that joints the femoral implant. The mechanical stress applied while walking is transferred to the piezoelectric components which use it to generate electrical energy.

The findings showed low energy generating capacity of the embedded PZT material. This was attributed to the low force of mechanical stress as well as the low coupling coefficient as a result of conversion inefficiencies.

Note: Source: (Platt et al, 2005)

# Reference Projects (Novel Shoes)

## Ashirase

Ashirase shoes were designed to enable visually impaired people to easily navigate their surroundings with the aid of vibration devices attached to the front, back and sides of each shoe. This enables the user to feel vibrations that guide them on their route. The technology is connected to a smartphone app so users can enter their destination address and uses satellite positioning data to optimise the route.

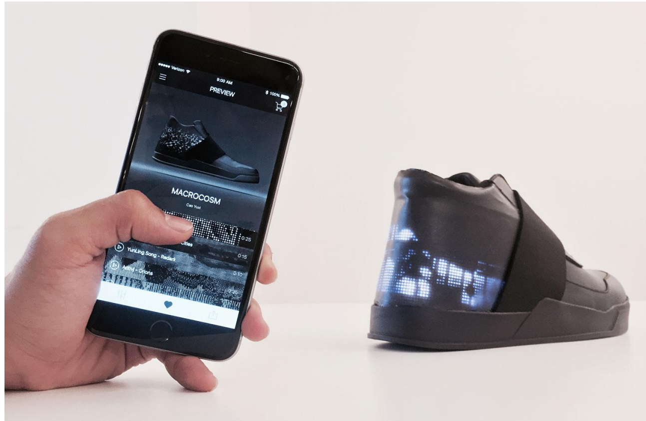
*Note*. Source: (Bellan, 2021)

## SolePower EnSoles

EnSoles were designed to harness the kinetic energy a user produced when walking to spin a miniature electromagnetic generator in the sole that stored electricity in a battery pack attached to the tongue of the shoe. The energy stored in this battery pack could then be used to charge mobile devices without using a wall power socket, additional batteries or electricity from the grid.

*Note*. Source: (Gambino, 2014)

## Vixole



Vixole shoes were designed to enable its user to customise the back of each sneaker's appearance with icons, animations and photos. This is made possible by a flexible LED display that wrapped around the back of the shoe which connected to a mobile phone app. It also incorporated motion sensors that could alter the shoe's appearance based on the user's movements.

*Note*. Source: (Dormehl, 2016)

# Reference Projects (Novel Shoes)

## Nike HyperAdapt 1.0

HyperAdapt 1.0 shoes were designed to increase user convenience with a self-lacing mechanism. By placing their feet within the shoes, they automatically and ergonomically tighten thereby eliminating the need to bend over to tie them. An LED light bar on the outer side of each shoe indicates the current charge level of the self-lacing mechanism which on average lasts for two hours on a single charge.

*Note*. Source: (Reisinger, 2017)

## Zellerfeld

Zellerfeld operates differently to most other footwear brands. The company 3D prints its shoes to user preferences using thermoplastic. As all of their shoes are made-to-order, they are uniquely able to avoid material wastage in their manufacturing process. The shoes are also recyclable where after their end of life, the shoes can be returned to Zellerfeld who can then recast them into a new pair of shoes.

*Note*. Source: (Burgos, 2023)

## Shift Robotics Shift Moonwalkers

Shift Moonwalkers were designed to augment the mobility of their user enabling them to travel up to approximately two and a half times the average walking pace or 11 kilometers per hour. This is made possible by eight motorised and two non-motorised wheels embedded into the soles of the shoes. On average, the shoes are able to travel within a 10 kilometer range on a single charge.

*Note*. Source: (Heater, 2023)

# Development Stages of Design Process

Our initial prototype revealed many flaws in our concept:

- How does the user interact with the touch panels?
- How can we integrate the navigation panels to be less bulky in what is otherwise thin fabric?
- How big would the battery need to be to store a considerable amount of energy?
- How did the shoe know where the user was attempting to navigate to?

These would require a total redesign for the second iteration. We decided that there was no feasible interaction that could input navigation easily or implicity, and so decided to remove it. However, this meant our project no longer met the brief (specifically, the 'interact with a smart city' component). This brought us back to our core concept of a shoe that generated electricity, and to the drawing board on how we could integrate it into a 'smart city'.

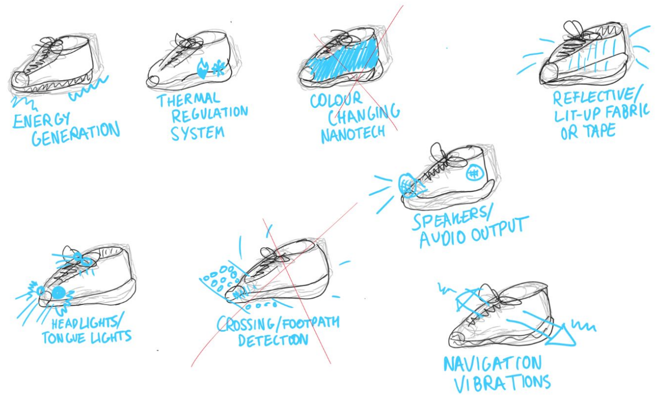
Albeit, throughout the process we answered many questions for aspects that remained relevant:

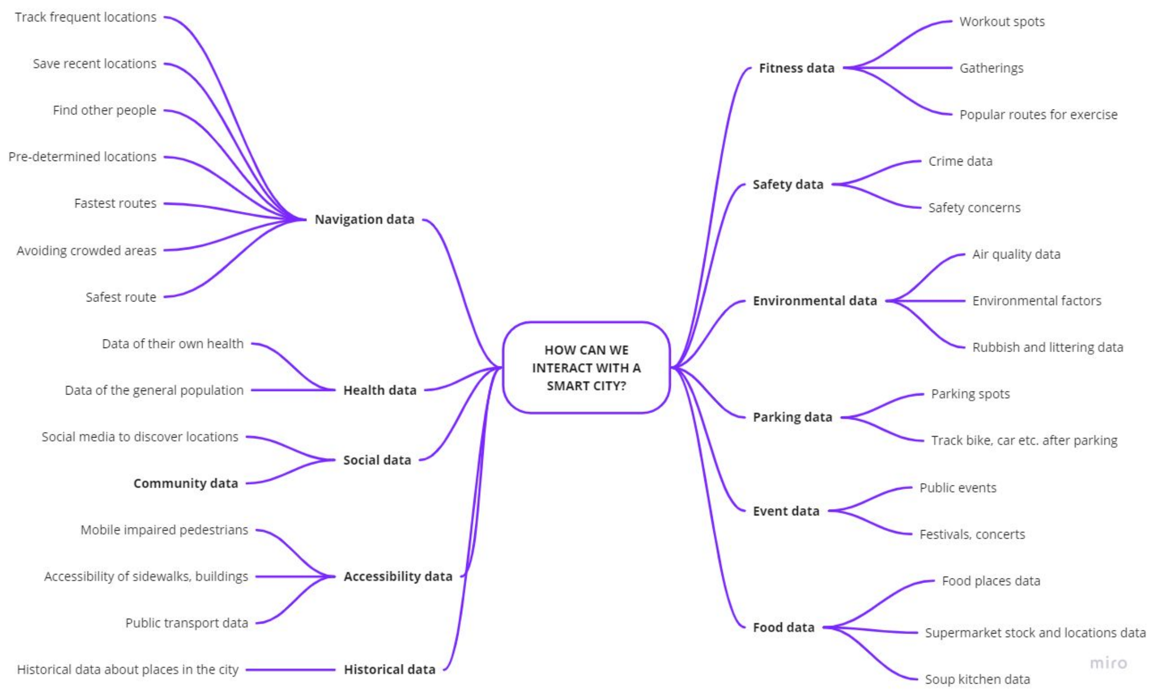
- Does the shoe maintain a small portion of its charge so that it stills function for the user before they have generated electricity? **Yes, it will.**
- How can we design a comfortable shoe that contains all of these elements? **Making them thinner/less bulky, and where possible integrating them into the sole.**
- How feasible is the piezoelectricity concept to develop electricity? **In its current form, and especially in ten years time, it is feasible.**

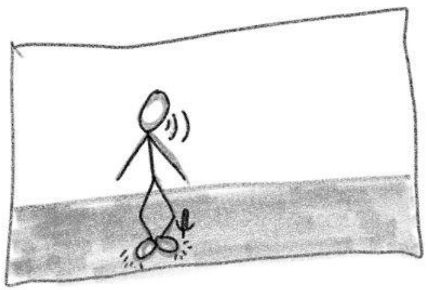
# Development Stages of Design Process

We continued to iterate by exploring a subsequent brainstorm of how we could 'interact with a smart city' as the primary focus.

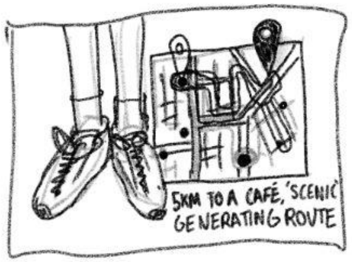
This proved to be very valuable as it enabled us to generate alternative ideas to those previously conceived. We drew up a narrower, more focused range of low-fidelity concepts:



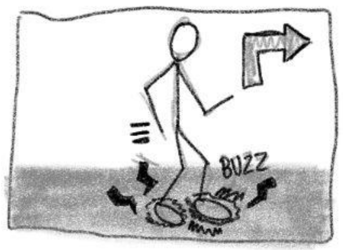



User wants to exercise, so they hold their heels and say "take me on a 5km scenic walk to a cafe"

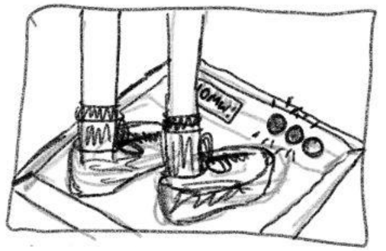



The shoes generate a mystery route, based on the parameters set. They blink green to indicate they're ready.




The shoes use vibration at turns to navigate the user, and generate electricity with each step. There are other features too, like thermoregulation and headlights.

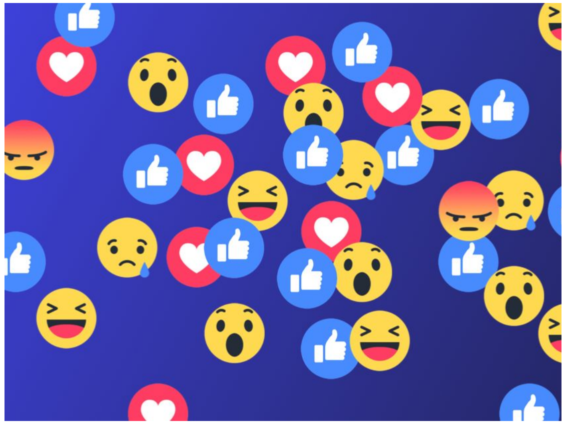

The shoes buzz long on both feet to signal they've arrived at their destination. The user can tap their heels to pause it and go inside.

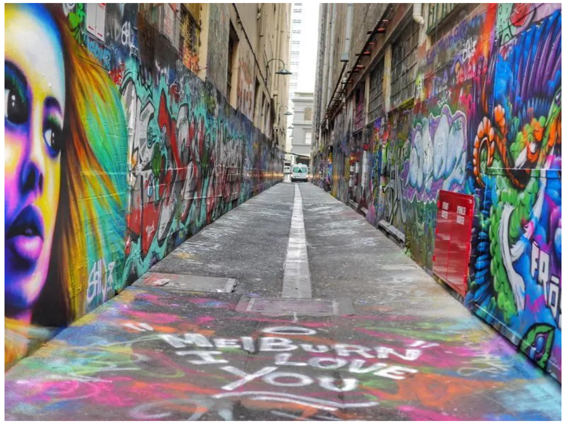


The user taps their heels to resume after their coffee, and then follows the navigation back to their starting point. They can reverse-wireless charge their shoes to transfer that energy to the grid.

# Development Stages of Design Process

This brought us to our successful concept: a shoe that did not necessarily navigate you on the most efficient route, but rather took you on an AI-generated journey to a destination, based on **social-popularity, landmarks, environmental beauty, accessibility, novelty, and distance,** to incentivise physical activity. These destinations would be categorised into different types including: nature, events, shopping, food etc.





For those who walk/run regularly, a common deterrent is how repeating same circuit can become monotonous (Hillnhütter, 2021). What if, instead, they could be taken on a new, mysterious circuit, with no idea of the destination other than its distance? Moreso, it provides an additional layer of fun that may outstrength procrastination for those looking to begin exercising outdoors.

This answered many of our current problems, while also providing a much-needed layer of intrinsic value for users that made our product more desirable.

- How did the shoe know where the user was attempting to navigate to? **Voice control enables input from the user to specify either a specific destination or it can algorithmically generate a path for the user that is unique.**
- Are all of the functions brainstormed appropriate to address the key problem areas? **In its second iteration, the shoe functions continue to appropriately address environmentally sustainable criteria through piezoelectric technology and now by implementing generative AI for routes, it meets the health and smart city criteria.**

With the intention of providing a complete solution, we brainstormed a range of foreseeable problem scenarios that the shoes would likely encounter when being used in the real world, and designed a range of responses to counteract them.

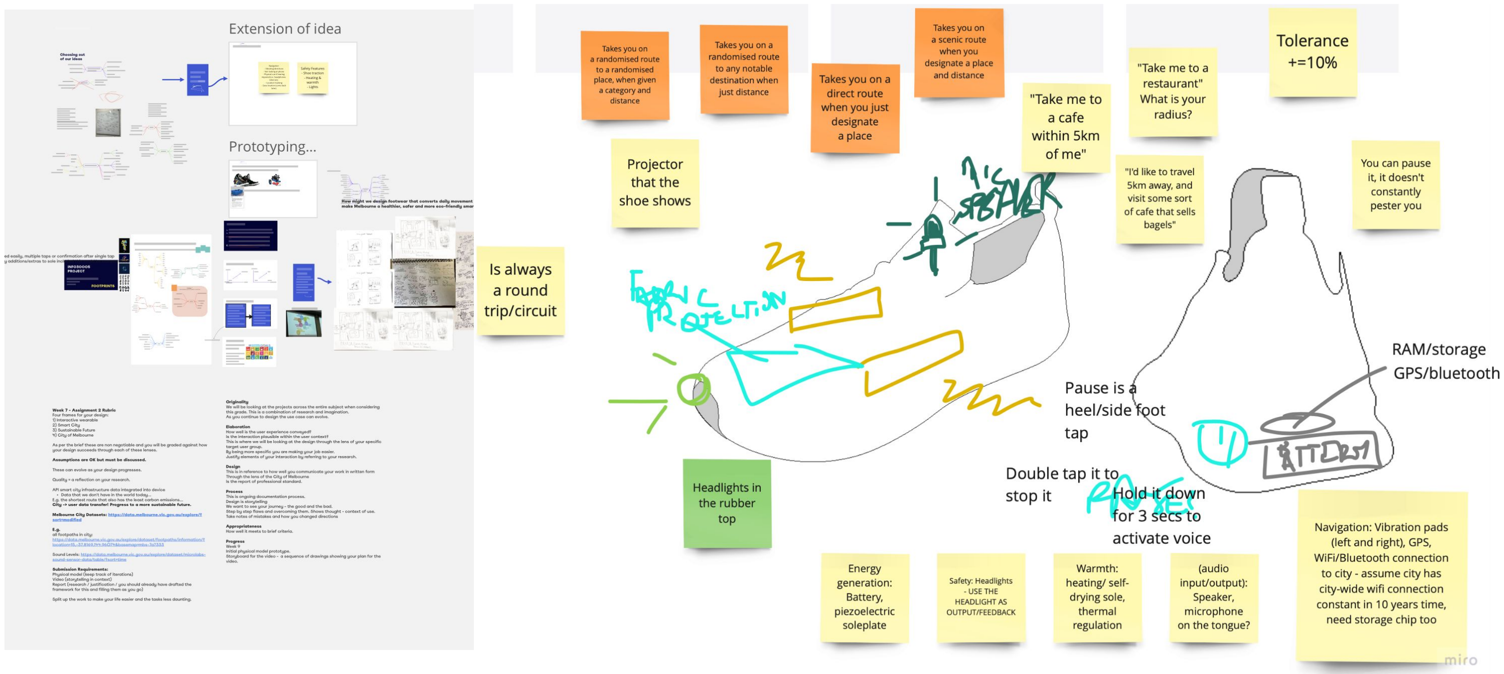
# Development Stages of Design Process

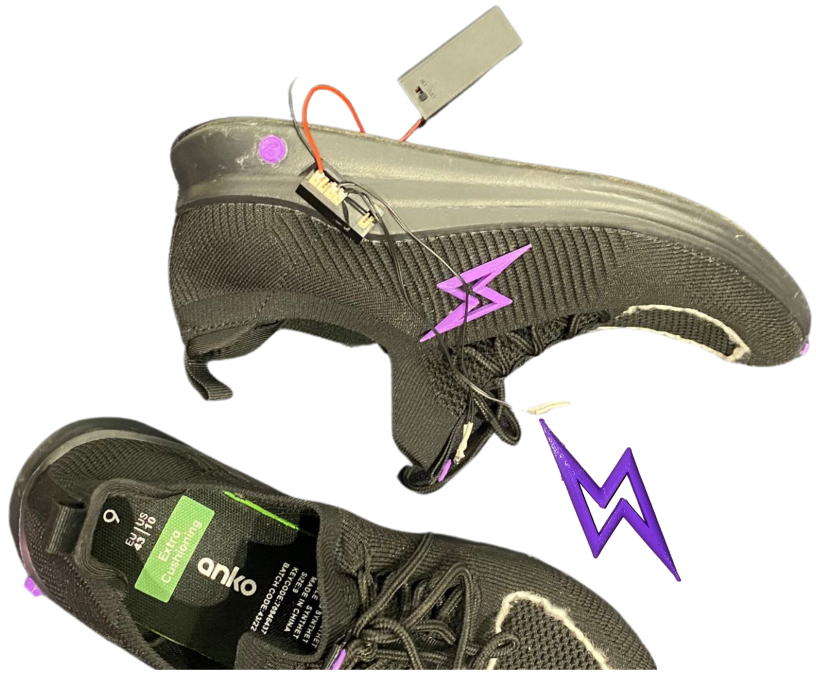
| Troubleshoot Scenario | Interactive Response |
|---|---|
| ***What if there are no appropriate destinations within the desired journey length?*** | After searching for all possible appropriate destinations, Footprints' headlights will flash red indicating an invalid input. |
| ***What if you are guided to a destination you do not like?*** | Simply activate voice control and specify an additional parameter for that destination (e.g. take me to a *jazz* concert). |
| ***What if you desire a certain type of destination (e.g. cafe of a certain cuisine or that has a certain menu item)?*** | Footprints will incorporate any additional parameters of the destination desired by its user and to the best of its ability select them. If it cannot, it will flash red. |
| ***What if you do not like the place it takes you to?***<br>***What if you want to change your destination mid-journey?*** | If you wish to return back to your origin or alter your journey, Footprints allows modifications to its route by activating voice control and specifying your new preference. |
| ***What if your route becomes blocked by obstacles?*** | Footprints will ideally generate a path with no obstacles using real time information on potential blockages (such as overflowing creeks); however, if there is an obstacle and the user takes a detour, Footprints will recognise this and regenerate a path in a different direction. |
| ***What if you are in a noisy environment, does voice control still work?*** | The attached microphone is highly directional and will only pick up on noise in the immediate vicinity of the user and will therefore still work in a noisy environment. |
| ***What if you begin walking on a slippery surface?*** | Footprints has in-built traction mechanisms that will create a non-slip sole of the shoe. These are inherent and require no interaction from the user. |
| ***What if you decide you want to exercise in low-light conditions?*** | Headlights positioned at the front of Footprints can be toggled to a continually lit state if given the voice command prompt: "Night mode". Can be turned off with "Night mode off" or will automatically turn off if it bright enough outside (using light sensors). |

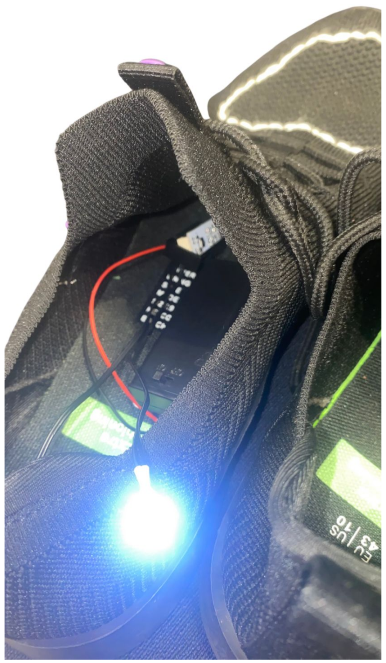
# Development Stages of Design Process

We then proceeded to create our final prototype and, for the sake of a ‘looks like’ prototype, we felt it more important to distinguish and evaluate the augmentations from the actual base shoe design.

For this reason, we used a pre-existing shoe to not distract us from the enhanced design concepts of our shoe. In the final product, we would ideally design our own, comfortable shoe that we could implement our technology in.



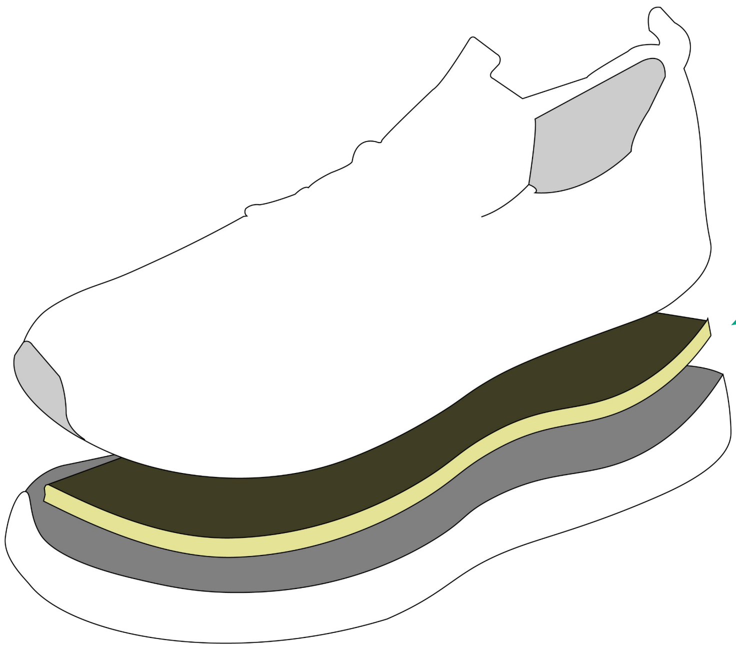



In our previous design, external attachments were clunky and didn't integrate well with the shoe. This time, we designed parts together with the shoe for a seamless fit. We incorporated textile fabrication for the fabric display to enhance coherence between the shoe and its additions.

The pieces were also designed to match their counterparts on the other foot and combine for interaction. Central to these modifications was ensuring that the shoe created a comfortable and engaging walking experience.

# Description of the Solution - Technology and Design

As a whole, we intended to create a shoe that was as sustainable as possible. In order to do this, we not only ensured that our underlying technologies maximised energy efficiency, but also that our shoe would be recyclable, sturdy and long-lasting to prevent contributing to any environmental-wastage issues.



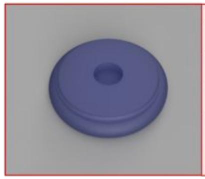
The piezoelectric harvesting plate is inserted between the insole and the midsole sections. The plate runs across the length of the shoe as opposed to being placed in one specific position such as the heel in order to capture the mechanical impacts from across the foot and attempt to maximise conversion efficiency and eliminate lost energy.

The battery shell and the vibromotor's outer casing are made of PLC thermoplastics as they perform all the necessary functions, eg. waterproofing, sturdy material, easy to clean, easy manufacturing and recyclability.

The additional components within the shoe, in order for it to be able to interact with a smart city and function properly, is a GPS chip, a Bluetooth/WiFi chip that is able to interact with the (future) city of Melbourne's 'smart maps' and receive this large amount of data on the different parameters users can offer the shoe, as well as a microcomputer to parse this information and calculate the routes based on these given parameters and API map data.

# Description of the Solution - Interactives

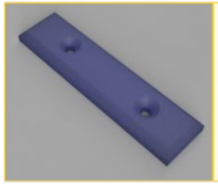
Our solution augments a shoe by adding electronic components both internally and externally to the traditional shoe design. In essence, the shoes use the heel panel (green box) to detect a heel click, then activating the microphone (red box) on the shoe's tongue. After receiving the input, the shoe's internal components then determine a circular path, through the desired destinations and back to the starting point, that totals the distance provided by the user.



The microphone is placed on the tip of the shoe's tongue overlay. It must be highly sensitive to pick up the user's voice without the need to lean down closer to the shoes. Software integration is responsible for blocking out background and excess noise.

The two part side panel is the user's initial interaction point, it picks up the heel click gesture and activates the voice control module. It can also be used for direct interaction as per the user preference.

The front face display uses smart fabric LEDs to create another avenue of system to user information flow that bypasses the inherent issues with the input/output system by giving the user an opportunity to revise the trip parameters and alter any major discrepancies with their preference.



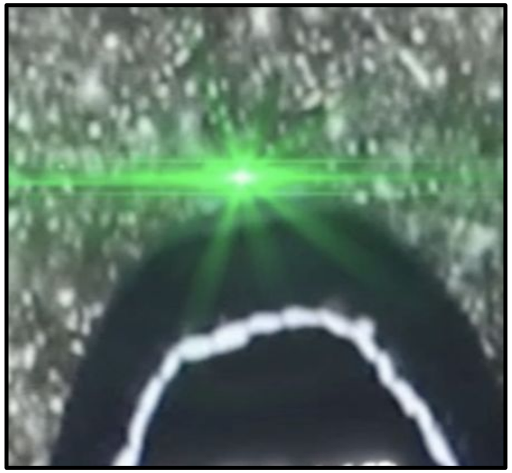
The light strip at the tip of the sole is essential for navigation as well as user feedback, the pieces are built with openings to allow for light connections. The lights can glow red, green or orange as needed.

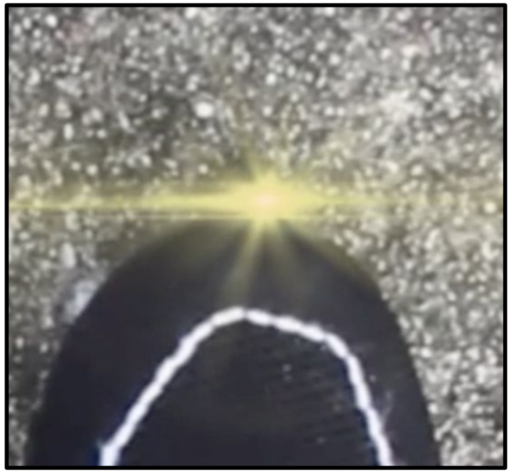
The lighting bolt shaped vibromotor doubles as the product logo. Attached to the outside edge of each shoe and delivers the vibrations that alert the user.

The shoes then respond with headlight and vibration indicators (yellow & purple boxes), as well as a pop-up display to guide the user (orange box).

# Description of the Solution - Output

The main form of output is the vibromotor on the side of the shoe, however the varied outputs when setting a journey are also prompted by the headlights; doubling as the output for users: telling them whether the shoe has successfully found a route (green), needs more input (yellow) or no route exists with the given criteria (red).





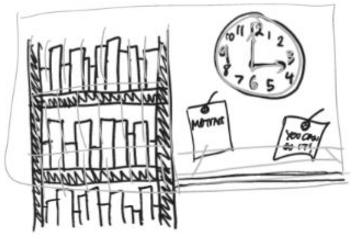
Potential combinations of user input:
A SPECIFIC LOCATION + A DISTANCE = Takes you the scenic route of that distance to that location
A GENERALISED CATEGORY + A DISTANCE = Takes you to a categorical location within the specified distance radius
NO LOCATION SPECIFIED + A DISTANCE = Takes you on a randomised route with a randomly chosen destination
A SPECIFIC LOCATION + NO DISTANCE SPECIFIED = takes user on the shortest path possible
A GENERALISED CATEGORY + NO DISTANCE SPECIFIED = N/A, an orange error headlight blink
NO LOCATION SPECIFIED + NO DISTANCE SPECIFIED = N/A, an orange error headlight blink

A green result will also buzz the shoe once, the yellow result will buzz twice, and the red three times.

# Walkthrough of Usage Scenario

We expanded our previous storyboards into some typical usage scenarios:

**1**



Bob is at his desk job in Melbourne's CBD. The time hits 1pm; lunchtime.

**2**

Bob gets up. It's a nice day so Bob decides he will get lunch out at a cafe.

**3**

Bob leaves the office and walks outside. He can't decide where to go, and is willing to try something new.

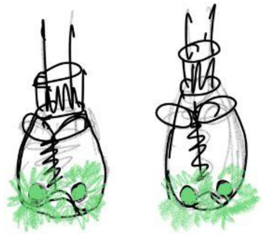
**4**

Bob is quite an active person, and knows he can walk about 4 km on his break for a bit of exercise.

**5**


He touches his heels together to activate the voice control and asks "take me on a 2km walk to a cafe"

**6**



The headlights blink green, the shoes buzz to indicate success and the display lights up.

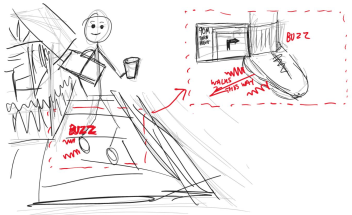
**7**

The shoes connect to the city's navigation data to begin a search in a 2km radius, selecting out of the many cafes based on data analytics on reviews, social media, cost, popularity and the walk to the place itself. They decide on the ideal secret destination, and then calculate the best route based on scenery, traffic, pollution, natural beauty and other data points.

**8**


Bob's left shoe buzzes to tell him to turn left. He begins his walk.

**9**




Bob continues to follow the buzzes of his shoes, turning at corners when prompted and excited about his lunch.

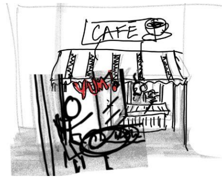
**10**


Bob is walking past a cafe when his shoes both let out a long buzz. He has arrived at his mystery destination.

**11**


Bob taps his shoes to pause the navigation.

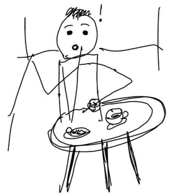
**12**




Bob walks into the cafe, and orders a bagel and coffee. He is pleasantly surprised with this cafe that he never knew existed, and enjoys his lunch.

# Walkthrough of Usage Scenario

13

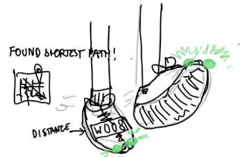


Bob looks at his watch and realises that his break is running out. He finishes his coffee and gets up.

14

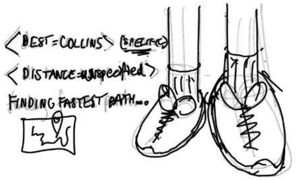
Bob steps outside, and to save time cancels his current scenic loop. He holds his heels together and asks "take me to 154 Collins St", his work.

15



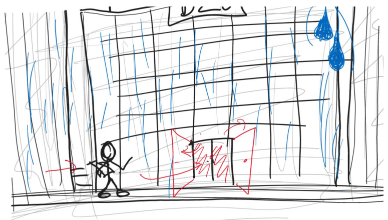

They light up green and the display shows a much shorter distance of 800m. Bob knows he can get back in time, and, relaxed, starts walking.

16



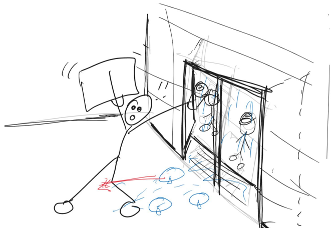

The shoes, not given a specified distance, found the fastest path based on traffic, shortcuts and construction work data.

17



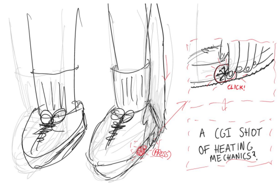
It begins to rain as Bob reaches the office, and rushes inside.

18



Inside, Bob's wet shoes cause him to slip and slide on the wet floor!

19

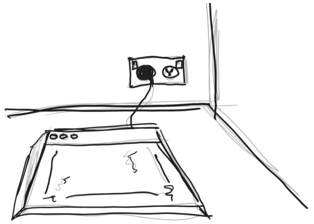



[Needs to be changed*] The heat function is activated by pressing a button on the side of the shoe

20

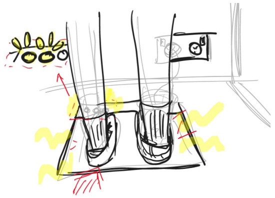
Bob continues on his way, his shoe soles now being dry and safe.

21



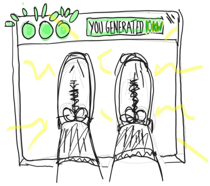
Bob approaches the charger pad, which is plugged into the wall.

22



Bob steps onto the charger pad, where the pad lights up and begins showing two status dots that it is charging.

23



The charging pad lights up green to indicate it's finished charging, showing Bob the electricity he generated on his walk.

24

A co-worker approaches Bob and tells him how much electricity he generated today wearing the shoes. It's a competition!

25


They are laughing and hi-five each other, supportive of each others' achievements. They walk towards the elevator.

26

They look at each other and decide to take the stairs instead to generate extra energy.

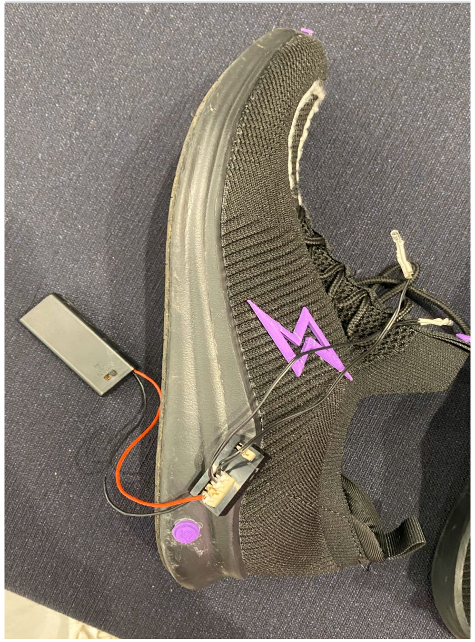
# Evaluation of Solution Effectiveness

## "Interactive wearable"

The design sought to minimise the physical interaction between the user's hands and the shoes, instead opting for voice as the primary input as well as taps between feet. While this prevents the user from bending over to reach down or forcing the user to make unhygienic contact with the shoe, it may feel awkward speaking to an inanimate object.

To counteract this, we lessened the amount of input the shoe requires to simply a category of location and distance. This way the user will only have to speak, at most, one sentence to get the full capability of the shoe. Other interactions such as directions and safety features are implicit (i.e. vibrations when needing to turn) as to make the experience feel seamless.

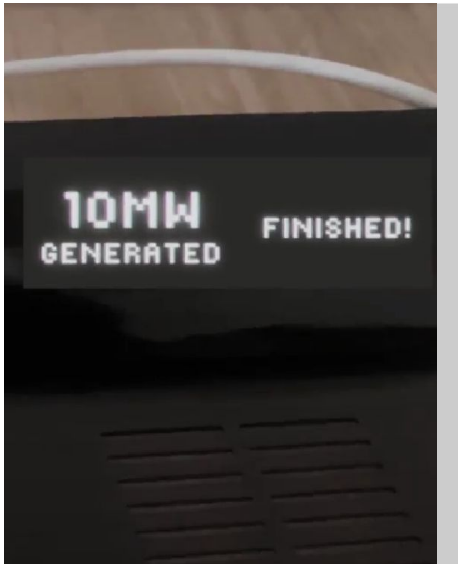
Furthermore, there were also issues regarding the size of the additional attachments, such as the vibromotor and sensors. This made the shoe look and feel clunky; however, this was addressed early by minimising the number of and size of attachments.



Although, due to the large amount of technology within the shoe, like the generative AI and piezoelectric sole plate, their may be some unavoidable weight which could affect the shoe's comfort.

# Evaluation of Solution Effectiveness

## “To enable a sustainable future”




The primary sustainability is the shoe’s self-sustaining energy through piezoelectricity. There is no need for external power or batteries which may be harmful to the environment, allowing the shoe to create its own power. Excess power from the shoe can also be transferred to the city electricity grid through the electricity transfer pad, allowing the user to reduce their carbon footprint.

Moreover, this promotes sustainability in regard to health as in order to charge the shoe, the user must actually use it, by either walking or running, promoting physical activity. To prevent the issue of the shoe not having enough charge, it will always retain a small portion of energy so the user can start their journey.

Furthermore, this shoe relies heavily on the assumption that piezoelectricity can generate enough power to be self-sustaining. If this assumption fails, the shoe is therefore no longer feasible unless externally powered through batteries, which undermines its environmental sustainability.

Overall, the self-charging capability of the shoe ultimately encourages physical movement and therefore makes its user’s healthier and more eco-friendly.

# Evaluation of Solution Effectiveness

## "Smart city"


The shoe incorporates data from a smart city like Melbourne, receiving data regarding navigation, city hotspots, greenery and foot traffic to name a few. The shoe then uses this data to generate a picturesque path for the user to take their mystery destination (integrated with City of Melbourne mapping, traffic and hazard APIs). While the data has a variety of different locations/potential paths, it may not be favourable for all users, thus potentially discouraging them from reusing the shoe.


Although, to mitigate this issue, the shoe will learn from the user's locational data, understanding how long they stay in certain locations and use that to guide the mystery location suggestion. This could be viewed as unethical, but since this has the same functionality as a mobile phone we are relying on the assumption that it will not be viewed as intrusive, especially since it will improve the overall user experience.

# Individual Reflections (Design Process)

This project was completed as a group of vastly different ideas and personalities that ultimately designed a gratifying final prototype:

I, **Lucas**, believe that there is great potential for Footprints to inspire exercise through both novelty and a helpful, positive core mechanic. I myself would love to switch up my monotonous running routes and be inspired by something new and exciting. The brief's problem space contained many parameters: "interactive", "wearable", "for citizens", "smart city", "Melbourne", and "sustainable future". This made coming up with a solution reasonably challenging, as often our ideas would meet some of the brief well, but forget about other aspects. For this reason, I believe Footprints was a great success in reflecting the problem in its entirety. If we were to complete this project again, I believe that some high-fidelity ideation would've greatly assisted in then creating the prototype, as there was a gap between the low and medium-fidelity concepts we established which caused us to come up with ideas on the spot whilst prototyping. However, our final product was something I am quite proud of and believe that despite this lack of late-stage ideation, we communicated well to build a thorough solution.

I, **Matiss**, believe that Footprints offers a user experience for urban citizens that no shoe to date can. Wanting to create a useful and innovative device meant that we were very explorative in our design process. We carefully considered what problems Melbourne urgently needed addressing and how those could be solved by almost any citizen living in the city. The success of the device I think is primarily due to our research, the utilisation of a double diamond design process, and the project team we had that really helped to inspire and encourage innovation. While Footprints provides a unique walking/running experience, I think there is potential to develop the concept further by incorporating more detailed ways of informing users about renewable energy they generate and investigating how that could be made both challenging and rewarding. But, I finished the project thinking: just imagine if everybody wore these shoes, what kind of health and environmental impact they would have, and that is why I believe our project is a solution that can enable a more sustainable future.

# Individual Reflections (Design Process)

I, **Omar**, believe that our project takes a unique approach to novel technology design, with a core focus on pushing users to lead a healthier lifestyle and providing them with a new avenue of excitement and entertainment, all whilst contributing towards a more sustainable wider environment. In our design approach, there was an immediate inclination to think outside the box and find a unique solution to the challenge provided by the brief, this took us down a route of exploring a wide number of options with each group member contributing a selection of novel ideas. This creative collaboration was crucial and carried on after finalising our core idea and underlying technology. Despite the frequent brainstorming we sometimes struggled to generate ideas to overcome certain roadblocks and criticisms, interestingly I believe this was often due to a tendency to be overly critical of ideas before giving them a real chance, which was something I was personally guilty of. I believe the brief was intentionally defined in a way that pushes us to explore those outlandish ideas and not be held back by the limitations of current technology and I think at times we could have done well to remind ourselves of that. Overall it was a thoroughly enjoyable experience working with a talented team to research and conceptually develop an exciting final prototype that aptly addresses the brief, but also goes beyond to produce an interesting and exciting project that we can be proud to have worked on.

I, **Stefan**, believe that we successfully created a prototype that fulfilled the three specific requirements: smart city integration, sustainability, and interactivity. One notable advantage of our design is that it minimally intrudes on individuals' personal space, as opposed to items like hats or bracelets, since everyone wears shoes. Despite my reservations about our choice of voice control as the input method, as it feels somewhat tacky and awkward to converse with an inanimate object, the alternatives that required physical touch on the shoe seemed even less favourable. Nevertheless, I would be willing to use our as it would enable me to explore different paths in my area; however, the initial novelty of the prototype may diminish over time since the emphasis is on the journey rather than solely the act of running. Furthermore, some extra mental effort would be necessary to ensure I stay on the correct path. Overall, it seems to offer an enjoyable experience for leisurely walks and runs. Regarding the actual design process, we could have asked for more feedback from people external to the group to determine the feasibility of our ideas, since we were inherently biased to what we had come up with and assumed it would work which lead to drastic stages between different fidelities. However, by actually engaging with a physical prototype and mimicking how it would work, we were able to identify issues ourselves, making it a valuable way of building on our design. I very much enjoyed the practical aspects of this process and felt it made it easier to come up with a solution that could satisfactorily address all parts of the problem space.

# Individual Reflections (Contributions)

This project was also completed in such a way that each person contributed almost equally to its successful completion:

I, **Lucas**, focused primarily on the design and visual aspects of the project. Significantly, this included the video, which I took on as my own responsibility. I also completed the storyboard sketches, and medium-fidelity sketches of the prototype. Within the report, I was in charge of the visual report design (fonts, colours, prototyping images), and completed the slides that document the design process. I was also involved within the ideation/brainstorming process, participating and scribing during these brainstorm sessions onto Miro. For the prototype itself, I sourced the shoe, and installed the buttons, microphone, logo onto the shoe in order for a usable prototype in time to shoot the video. Personally, I enjoyed everything that this project had to offer, and feel I have a greater understanding of project management, ideation, prototyping and video/report creation - really consolidating many of the skills I have acquired in one wholistic project. If I could offer a personal critique, it would be to ensure to communicate with the team more frequently on progress and particular decisions, rather than making assumptions. In some cases, I would have to alter work after falsely making assumptions on components we had decided differently on. In future projects, I would definitely keep this in mind in order to better myself as a team player.

I, **Matiss**, mainly contributed by creating the narrative for the project. I was responsible for defining the design brief, investigating the problems that Melbourne faces, researching the current approaches in place for addressing the problems and evaluating those approaches to identify novel design opportunities. I also sourced problem data, images and icons, which with them, created graphs and visual representations to illustrate key details in each section. Furthermore, I explored novel shoe designs in industry today that inspired our own design and actively participated in group ideation/brainstorming sessions.

I, **Omar**, contributed mostly towards the prototyping elements of the project by designing and modelling all 3D attachments for early iterations as well as final pieces with help from Stefan. I was also responsible for researching and confirming the practical feasibility of solution decisions and subsequently supporting the team during brainstorming and ideation processes. This involved deep research into the relevant technical concepts and underlying technology. This research is reflected in my contributions within the reference projects and solution description sections of the report.

I, **Stefan**, predominantly focused on the prototyping aspect of the project as well as the ideation. In the early stages, I led brainstorming sessions that played a pivotal role in shaping the initial concepts for our design. Moreover, I assisted Omar in the development of the shoe's 3D components, carefully selecting their arrangement and overall shape and size. I also made valuable contributions to various sections of the report, including an in-depth analysis of the effectiveness of our solution, comprehensive coverage of the design process, as well as overall editing and proofreading.

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