Cycling Design Challenge

University of Birmingham - Human Computer Interaction

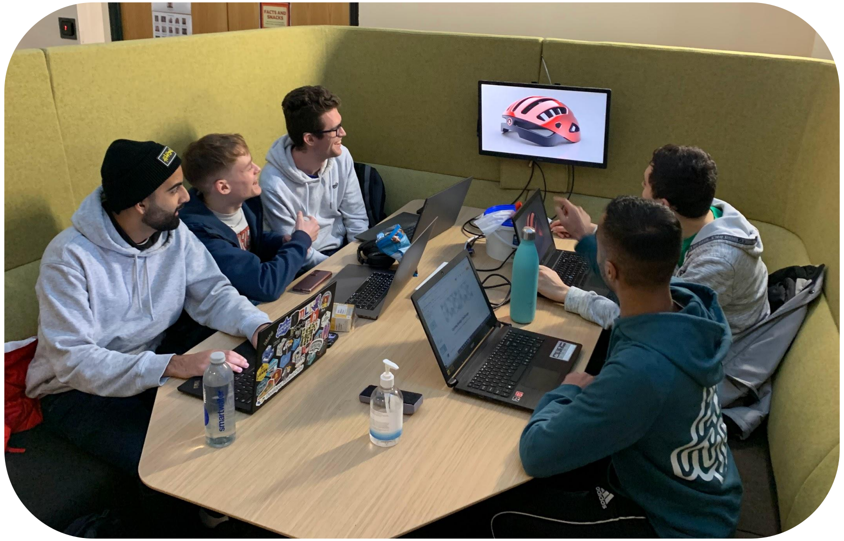
Group 26: Ben Stein, Eesa Kasujee, Nicolas Poffley, Ikum Kandola, and Matthew Dawson

Introduction

For this year's Design Challenge, we were tasked with designing a digital technology solution to improve people's experiences of cycling.

Our team designed the **Sixth Sense (6S) Helmet**, a smart helmet which offers front and back cameras to detect potential collisions and record journeys.

In this report, we will detail the **user-centred design life cycle** we followed to create the 6S Helmet.

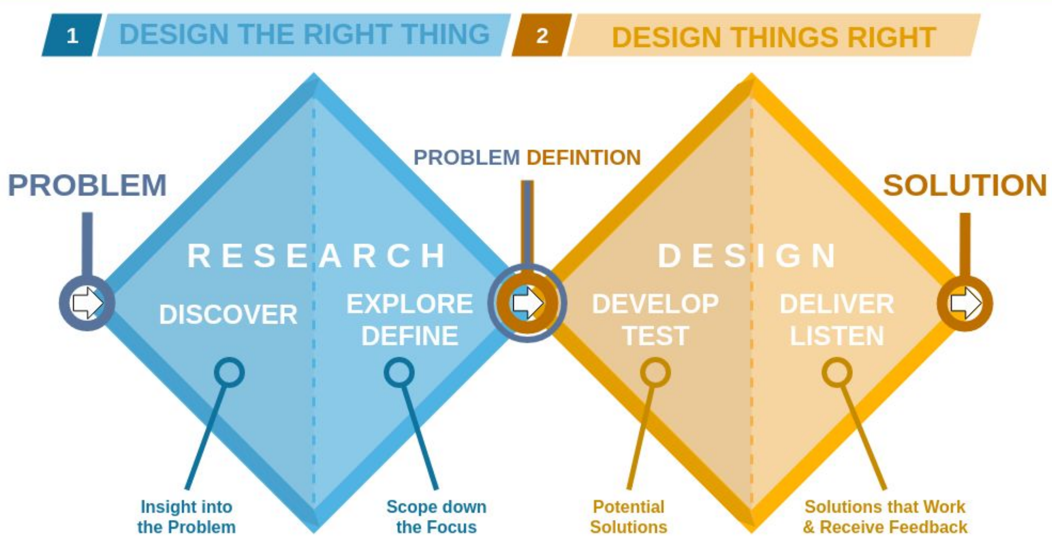


Design Process

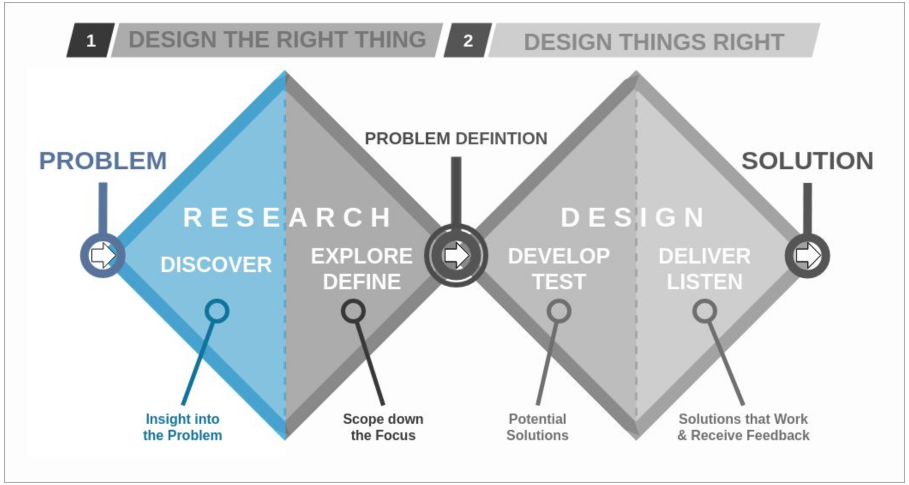
Throughout the design challenge, we will be closely following the **Double Diamond** design process model.

This framework has been proven to tackle some of the most complex problems when it comes to designing a solution. It encourages us to explore an issue more widely (divergent thinking) and to take focused action (convergent thinking).

The main caveat with this approach however is that it does not put much emphasis on iterative improvements. To counter this, we will need to consider making iterations throughout the process.



Problem Discovery



Problem Brainstorm Session

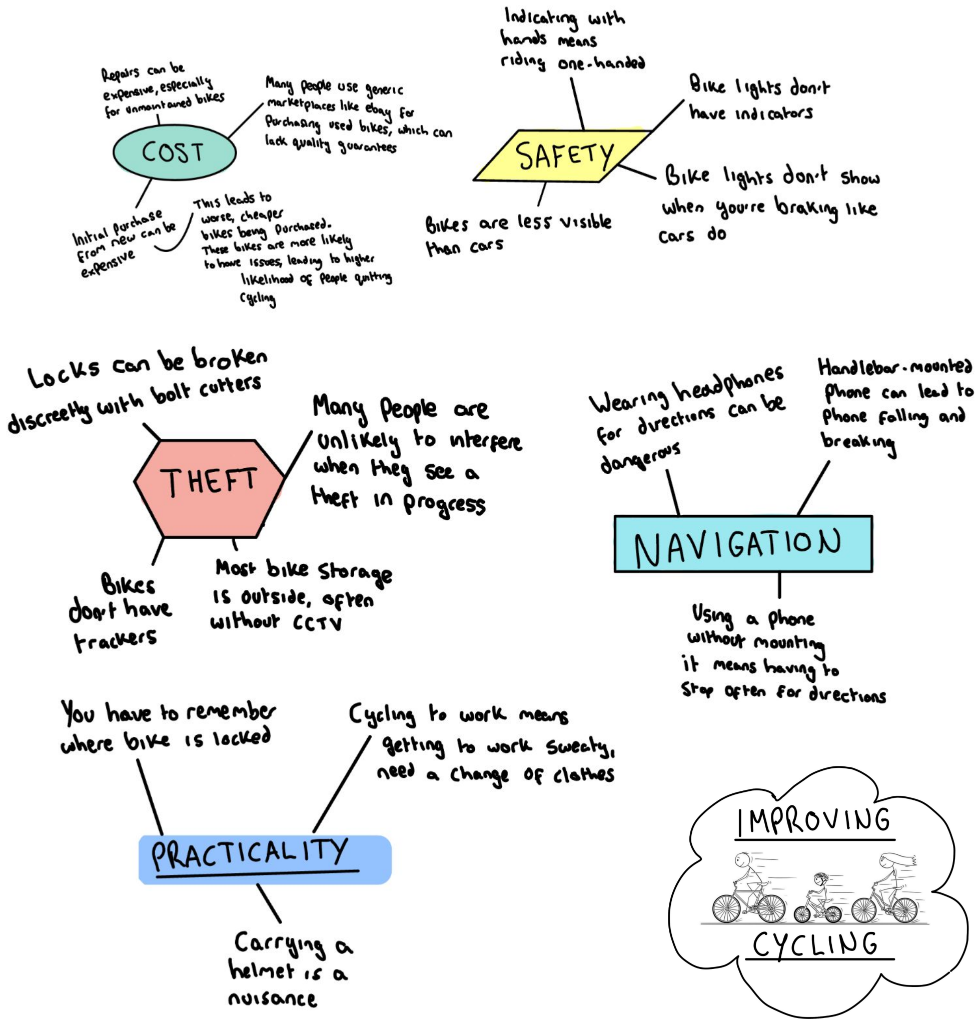
To start to identify potential problems cyclists often face, our group had an initial session where we discussed the brief and **shared known problems with cycling** and bikes, especially ones we had experienced ourselves. This allowed us to identify areas which might cause people to stop cycling or be reluctant to cycle.

In these discussions, we brainstormed these problems and grouped similar ideas into related categories to utilise a thematic approach to thinking of problems. Throughout this, we identified four key themes emerging: **Security**, **Safety**, **Enjoyment** and **Navigation**. We also identified other themes such as cycling conditions, cost and maintenance.

Problem Brainstorm Session

By initially brainstorming some problems cyclists may face, we were able to start to empathise with our target users and better understand their needs. Any problems we had identified would be added to the relevant section of the brainstorm which encouraged an open discussion amongst the group.

This provided a 'mile wide inch deep' view of problems within cycling which helped us determine an area to focus on and decide what issues our questions should be addressed in future surveys and interviews.



Problem Discovery

Although our initial problem brainstorm provided a good starting point in the design process, we had a somewhat limited view of the cycling issues as few of the group members were frequent cyclists and we only had a limited number of perspectives.

To further explore cycling problems, we decided that we needed to understand our target audience (cyclists) better in an attempt to explore the problems more deeply and then scope down the focus of the problem.

To do this, we are using two main techniques to better understand our audience/users:

Surveys - Inexpensive way of capturing the characteristics of a large population. Enables rich data analysis.

Interviews - Provides a clear insight into what users think about cycling. Informs the development of user personas.

Problem Focus

To narrow down the focus area of the survey and interviews and enable richer insights, we decided to mainly target these areas in the survey questions:

1. **Security**
   Bike theft is a large issue across the country, especially within university towns. With one of our group members having their bike stolen recently, we wanted to further understand why this is still such a large issue and what measures people are taking to store their bikes securely.

2. **Safety**
   Cycling is often perceived as a dangerous mode of transportation. To find out what precautions people take when cycling, we targeted the questions to investigate this, as well as any significant barriers to using safety equipment such as helmets.

3. **Enjoyment**
   Cycling can be a divisive hobby, with many people viewing cycling as a fun activity and those who dislike the idea of riding a bike. We wanted to investigate the level of enjoyment people have when cycling and understand the reasons why people may or may not want to cycle.

4. **Navigation**
   With there being so many different types of bikes available and many terrains to pick from, we wanted to understand what types of bikes people use, how people navigate when using a bike and where people tend to cycle.

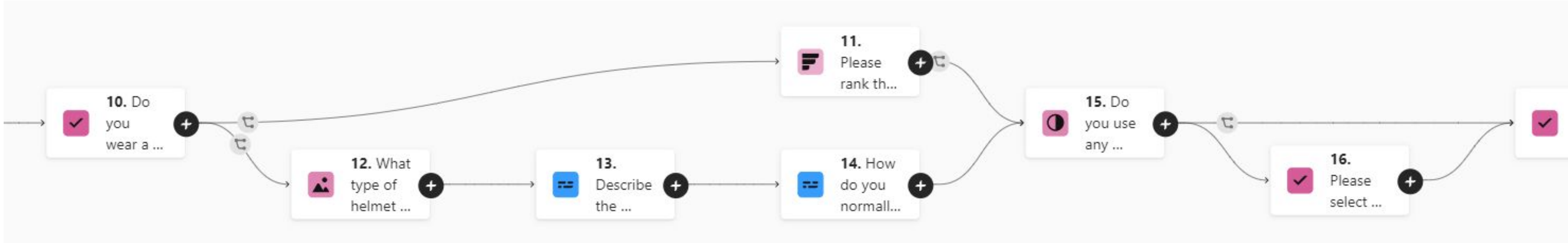
Survey Design

When creating the survey, we were careful to ensure that it was designed to **reduce survey fatigue** and **completion time** yet provide **actionable results**. Survey fatigue can happen when respondents become uninterested in answering the survey and is often a result of poor survey design (i.e. **long, boring and complex** surveys).

To minimise this, we designed the survey with the following principles in mind:

- The survey is kept **short** and **contextual**
- Provides an **estimated time** for survey completion so participants are aware from the start
- Offers **personalised** surveys through survey logic
- Provides **context** to encourage greater engagement
- Uses a **variety of question types**
- Give users the chance to offer open-ended **feedback** at the end of the survey

Survey Logic

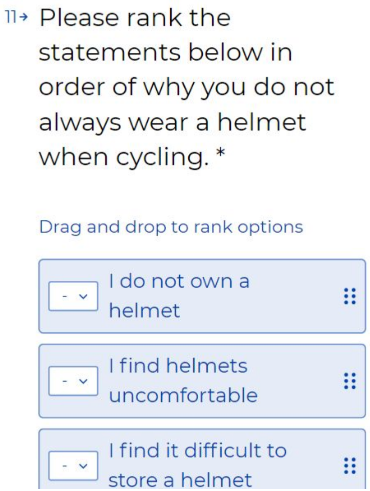


When designing the survey, we decided to implement survey branching/logic which allows certain questions to be displayed based on previous responses. For example, in one of the questions, we ask if the respondent uses safety or protective gear when cycling and only ask them to list which types they use if they responded ‘Yes’ to the previous question. Adding logic in this way provides the following advantages:

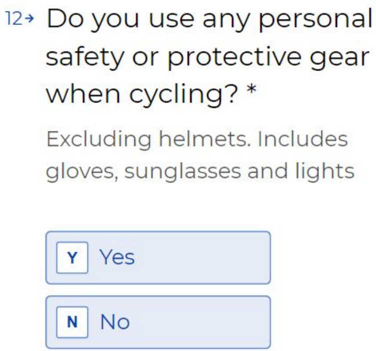
- Only **relevant** questions are asked
- The survey is **personalised** to the person completing it
- Reduces the **time** to complete the survey
- Increases survey **completion rate**
- Increases the chance that **more people** will take and complete the survey, providing more **reliable** results
- **Filters out** those who have never used a bike before

Survey Question Type Variety

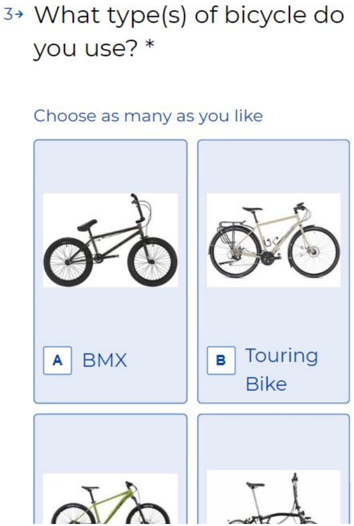
There are many question types available to use when creating a survey. Each question type has its advantages and disadvantages so we were sure to use the most **relevant question type** for each of the questions and to use a variety of question types to **reduce survey fatigue**.



Ranking question type



Yes/No question type



Picture choice question type

Survey Distribution - Online

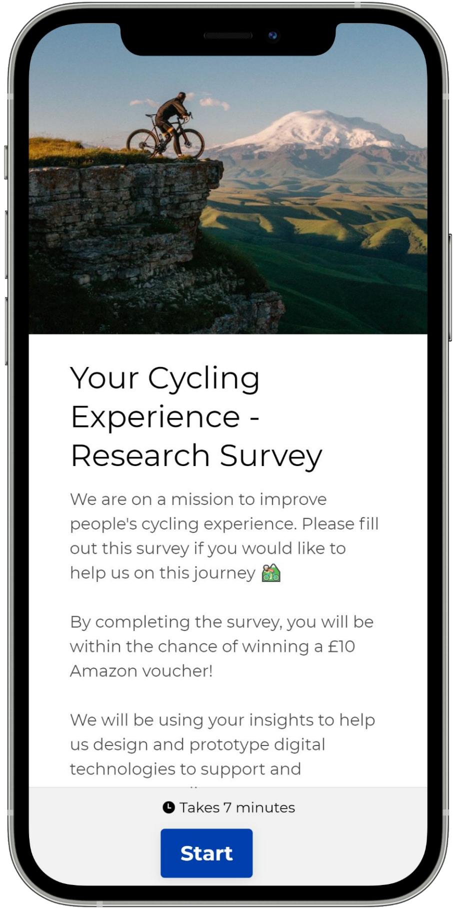
Online questionnaires offer many benefits over their physical counterparts. They:

- Are easier to share and fill out
- Result in increased response rates
- Offer rich data analysis features
- Faster and cheaper to conduct

We created a questionnaire using Typeform as the platform offers one question at a time, much like a conversation, helping to **keep our respondents engaged**. It also offers a **mobile-friendly** layout and survey logic, helping to facilitate **quality data**.

The survey can be accessed here:
https://tinyurl.com/cycling-survey

(Alternative link: https://01n5wk13vnq.typeform.com/to/nRCJxapd)



Survey Distribution - In-Person

As effective as online survey distribution can be, we quickly found that many of our respondents were students, many of whom did not cycle frequently. Furthermore, we didn't want to limit our respondents to just students and wanted to try to solicit responses from people with a **wider range** of experiences and preferences.

To help get a wider range of respondents, especially those who cycle regularly, we decided to print and place posters with a link and QR code to the questionnaire. The use of a QR code makes it more likely that people will visit the site rather than typing in a URL. To **incentivise respondents** to complete the form, we also introduced a reward in the form of an Amazon voucher.

We placed these at bike shelters at various places around Selly Oak (near the Edgbaston campus) in the hope that cyclists would notice the poster and fill out the survey. However, this location will still inevitably result in a bias towards student respondents and is something we will need to consider when analysing the results.

Do you cycle? Complete this short survey to help us understand the problems that cyclists face

tinyurl.com/cycling-survey

For a project by UoB students to see how we can improve people's cycling experiences
By completing, you'll be entered into a draw to win a £10 Amazon Voucher

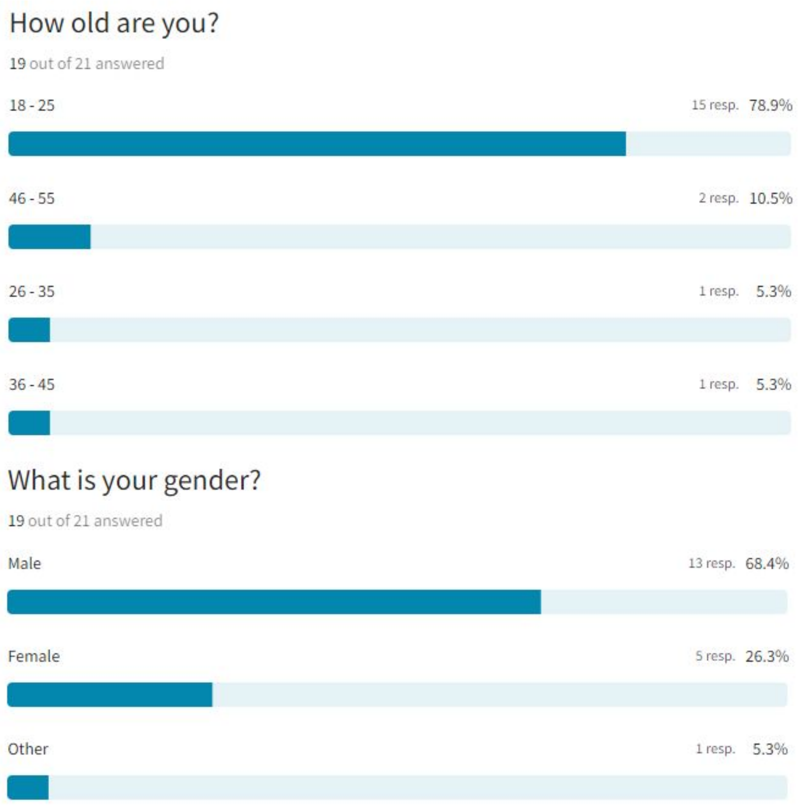
Survey Responses Analysis - Demographics

Before starting to understand and analyse the responses to our survey, it is worth considering the demographics of the respondents.

In total, we received 21 responses to the online survey. Ideally, to get a **more representative** data set, we would like to have had around 30 responses but were unable to find enough respondents in the limited time we had.

Although we attempted to get a diverse range of respondents, the majority of them (~79%) are aged between 18-25 and are male (~68%). This means that the key problem areas we identify from the responses are likely to impact **younger male cyclists** but we are likely to miss any issues which impact **older, female cyclists**.

These limitations are something we will need to keep in mind when developing a solution, as we may only be solving an issue a small percentage of a certain demographic may experience.



Survey Response Analysis - Seasonality

We wanted to better understand cycling habits across different times of year to see if there was a preference towards specific seasons.

We found that in **winter 52.9% of respondents said they never cycle**, compared with only 11.8% of respondents in summer months. This significant difference suggests that substantial differences in weather conditions in the UK are likely to impact the decision to cycle.

The results inferred that the cold icy weather of winter can make **cycling less enjoyable** and potentially more dangerous for cyclists, which is a problem we could look to explore further later on in the design challenge.

How often do you typically cycle in each of the following seasons?

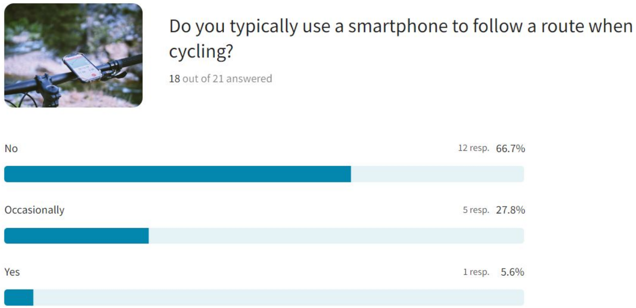
17 out of 21 answered

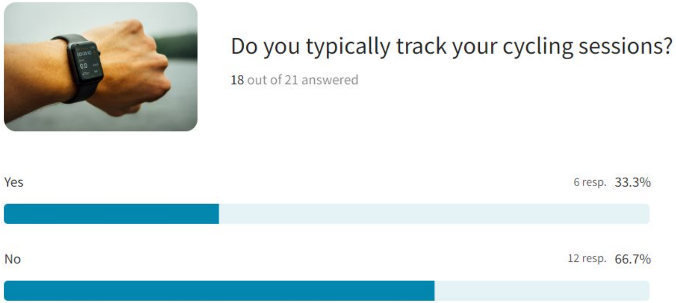
	Never	Occasionally	Frequently
Winter	52.9%	41.2%	5.9%
Spring	29.4%	47.1%	23.5%
Summer	11.8%	52.9%	35.3%
Autumn	35.3%	47.1%	17.6%

Survey Response Analysis - Cycling Technology

We wanted to find out about smartphone use and session tracking during cycling to better understand how technology is currently being used by cyclists. We found that **66.7%** of people **don’t use a smartphone** to follow a route while cycling and **only 33.3%** of respondents **track** their cycling sessions.

This shows the majority of people don’t utilise the available technology to guide them or track their sessions. This could suggest that are problems with the current technology out there which are putting off cyclists. However, it could also suggest that there is not much interest in this type of technology and it is not needed by most cyclists.



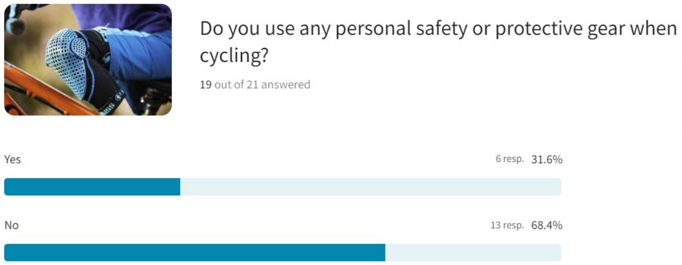


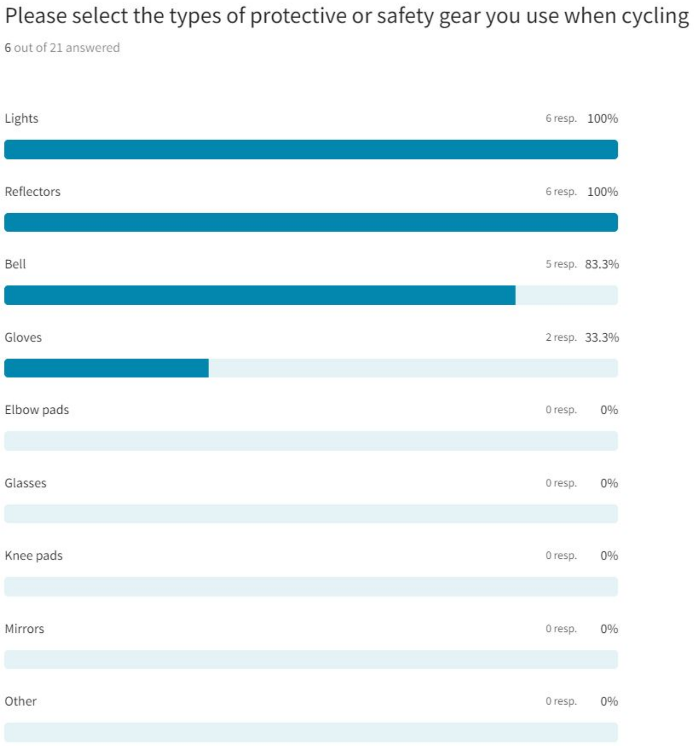
Survey Response Analysis - Personal Safety

To better understand how people protect themselves when cycling, we asked about the type of safety gear respondents wear when cycling, if any at all. We specified that this does not include helmets and we covered helmets in other questions. The respondents indicated:

- 68.4% don’t use safety gear
- Lights and reflectors are the most popular safety gear (100% of those that use safety gear)
- Elbow pads, glasses, knee pads and mirrors were used by 0% of those that use safety gear

This shows that most people don’t use safety gear apart from helmets, indicating that safety may not be taken too seriously when cycling



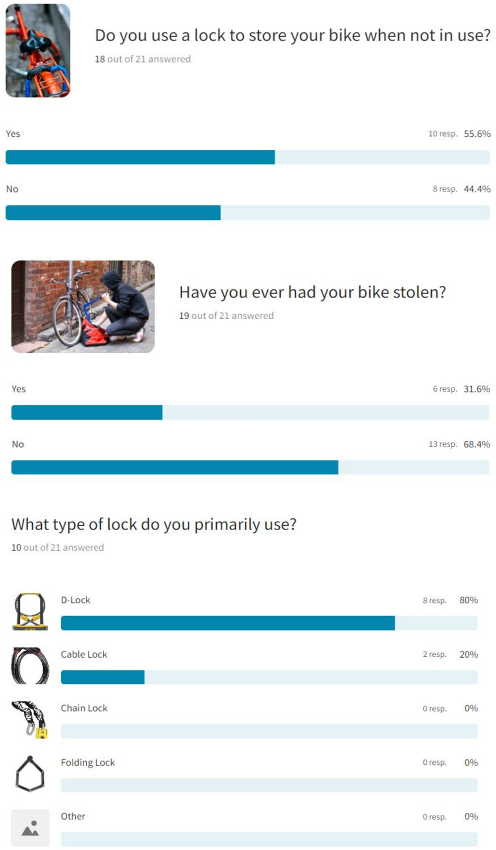


Survey Response Analysis - Theft

We asked respondents a number of questions to gain a further understanding of bike security and theft. The results showed that:

- Respondents rarely leave their bikes at work/school/university (27.8%)
- 55.6% lock their bike when not in use
- 80% use a D-lock while 20% use a cable lock (of those whom lock their bike)
- 31.6% have had their bike stolen with 50% of those due to no lock
- No one was able to recover their stolen bike

We found these results to be surprising as 31.6% of respondents having their bike stolen is a very significant percentage and something we could aim to solve with our solution. This could be a reason why only 27.8% of respondents leave their bike at work, school or university.



Survey Response Analysis - Cycling Attitudes

Please choose the degree to which you agree with the following statements.

19 out of 21 answered

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I find cycling an enjoyab...	5.3%	0%	5.3%	63.2%	26.3%
I always have the energy ...	15.8%	31.6%	26.3%	26.3%	0%
I never worry about...	36.8%	31.6%	21.1%	5.3%	5.3%
I prefer cycling to other...	15.8%	42.1%	15.8%	26.3%	0%
I find cycling a safe...	10.5%	26.3%	31.6%	31.6%	0%
I find cycling alone...	10.5%	47.4%	21.1%	15.8%	5.3%
I would like to cycle...	0%	11.1%	22.2%	50%	16.7%

To better understand issues our respondents may have with cycling, we added a **matrix question** with a variety of statements about **attitudes towards aspects of cycling**. They then had to select the degree to which they agree with each of these statements.

The respondents indicated that:

- Cycling is an enjoyable activity (for 90% of respondents)
- Some (45%) struggle to find the energy to cycle
- Many (over 65%) worry about bike storage
- Cycling is often not the most preferable mode of transportation
- Cycling is seen as a somewhat safe activity
- Most (60%) find that bike riding is not a lonely activity
- The majority (66%) would like to cycle more often

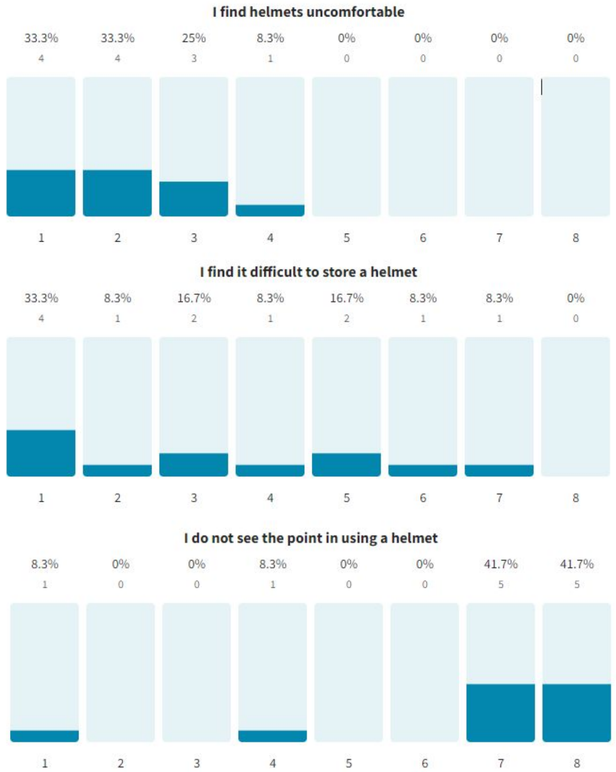
The key finding from this question was that **bike storage** was unanimously a key issue amongst our respondents.

Survey Response Analysis - Helmet Usage

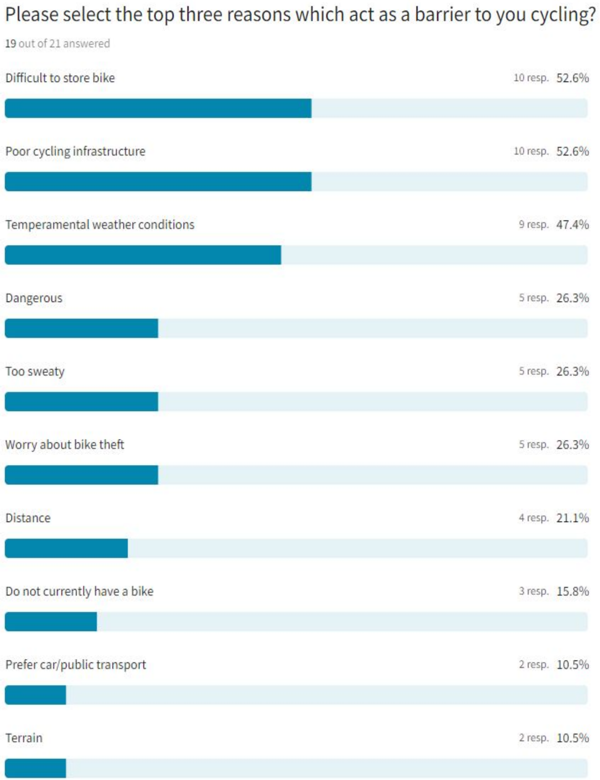
To further identify issues our respondents may have with **using a helmet**, we added a ranking question with a variety of statements about **attitudes towards using a helmet.** They had to rank the statements in order of importance as to why they may not decide to wear a helmet. This question was only shown to respondents who do not select ‘always’ when asked if they wear a helmet when cycling to ensure it only targeted those who sometimes struggled with helmet usage. On average, the respondents who do not always wear a helmet indicated that their justification for doing so is that:

- Helmets can be uncomfortable (with 33% of respondents ranking this statement highest)
- Helmets can be difficult to store (also with 33% of respondents ranking this statement highest)
- Helmets often ruin people’s appearance and can put people off wearing helmets

The most significant finding from this question was that over **90% of respondents understood the importance** of using a helmet but **storage and superficial barriers often prevented them** from wearing one. This indicates that the current range of commercially available helmets does not solve these issues.



Survey Response Analysis - Barriers to Cycling



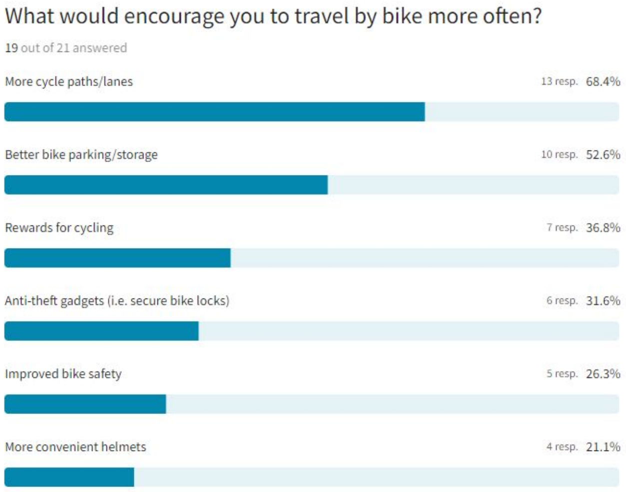
To understand the barriers which exist for cycling, we added a multiple choice question which asked respondents to select the **top three reasons which may prevent them from cycling** so only the most important reasons were highlighted in our results. The results showed that:

- Over 50% of respondents struggle with storing their bike
- Many (~50%) experience poor cycling infrastructure
- Weather conditions prevent 47% of respondents from cycling
- Around 25% worry about bike theft

The concerns raised from this question were that **bike storage, safety, theft and weather conditions** pose significant barriers to cycling. To better understand these issues, we asked about them further in our user interviews.

While cycling infrastructure was also an important aspect, due to time and budget limitations with the design challenge, we have decided to focus on aspects which are more accessible and solvable.

Survey Response Analysis - Encourage Cycling



To develop a greater understanding of the type of solutions which would encourage our respondents to **travel by bike more often**, we added a multiple-choice question which asked them to select the relevant reasons. The results showed that:

- Over 68% of respondents wanted more cycle lanes
- Many (~52%) would like better bike parking and storage
- 37% of respondents would like to be rewarded for going on bike rides
- Around 32% would be more encouraged to cycle if there were better anti-theft gadgets

The common finding from this question was that - once again - **bike storage, safety, theft and infrastructure** pose barriers to cycling and we will use these key insights in developing a solution.

Although more cycling lanes were desired by our respondents, due to time and budget limitations with the design challenge, we have decided to focus on aspects which are more accessible and solvable.

Ethnography

We also decided to conduct ethnography (observing users in their natural environment) to find and understand any common problems we **couldn’t identify from the survey**.

We observed the behaviour of cyclists at cycle stands, looking for any problems they might have been experiencing and asking questions to those who were encountering problems.

Key takeaways:

- Lots of cyclists were not wearing a **helmet -** when asked why they repeated answers from the survey (**comfort** and **storage**)
- Helmets were mostly attached to handlebars **insecurely** or **carried** by hand into buildings
- Several cyclists **struggled to find space** to lock their bikes, going to multiple bike racks before finding a suitable location

Despite these insights, our ethnography was **limited in utility** as it only highlighted problems faced near cycle racks, which are only a **small subsection** of cyclist problems.

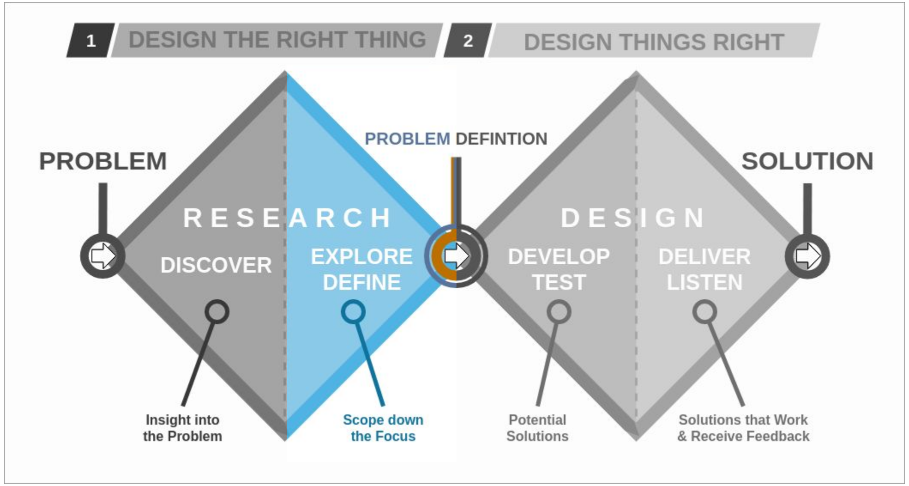
Problem Discovery Stage - Evaluation

Overall, we found our problem discovery stage to be highly effective. Our brainstorming session provided an abundance of cycling-related issues for us to explore. This allowed us to **design an effective survey** to explore these issues in greater detail. Furthermore, we found the survey to also be effective in identifying **cycling trends** in the local area, although we are aware that the data we have is limited by the number of respondents we had and could have improved the quality of the data by receiving more responses to the survey.

By utilising survey logic, our questionnaires were quick and simple to complete, ensuring **reliable data and insights**. However, we discovered that the demographics of the respondents are slightly biased towards young males due to the nature of the course and acquaintances of the group members.

Ethnography was somewhat helpful and eliminated some of these issues towards biased data as we were able to observe cyclists from a range of ages and backgrounds. We do need to keep in mind however, the insights from this technique are **limited in utility** as it only highlighted problems cyclists face near cycle racks.

Problem Focus



Focus Areas

Based on the survey analysis, we decided to narrow down our focus to two key problem areas identified: **bike security** and **cyclist safety**.

Narrowing down our focus allows us to have **greater depth** in our exploration of problems and solution ideas. We chose these two areas as they were commonly reported in the survey as problem areas:

Bike Storage

53%

Of respondents reported storing their bike safely as one of the biggest barriers to cycling

Helmet Usage

63%

Do not use a helmet every time they cycle due to some of the difficulties related to helmet usage

Indication

60%

Of respondents find it difficult to indicate whilst cycling

In-Depth Interviews

In addition to the surveys, we opted to follow up with a few further in-depth interviews. We aimed to **gain further insight** into any potential problems - surveys are very useful to gain a broad understanding of issues, but as respondents are not obliged to provide further reasoning behind answers, the results are unable to provide a **thorough understanding** of the issues.

Using the survey responses, we constructed a **semi-structured interview** to gain further insight into the popular survey responses. The semi-structured approach was used to give **flexibility** so that interviewees could follow up questions with their own narrative and stories, giving a much deeper insight than just a structured interview.

Interview Questions

1) **What's the main reason you cycle, and how many times per week do you do so?**

2) **Have you had any accidents cycling?**

3) **Has your bicycle ever been stolen?**

4) **Between safety and theft prevention, would you prioritise one of these areas over the other if you could improve it? Why?**

5) **What would you be willing to spend on something which could help with these issues?**

These are the base questions, which will be followed up on to gain more insight where possible. The interview focuses on the two areas of **security** and **safety**, the two focus areas chosen from the questionnaire results.

Interview - Emre - Daily Commuter

What's the main reason you cycle, and how many times per week do you do so?

I cycle every weekday to work except when the roads are icy. Saving money on my commute is the main reason I cycle, otherwise I'd have to spend money for the train every day to get to work.

Have you had any accidents cycling?

A few close calls but never a full-on accident. I ride pretty carefully, and on the cycle path instead of the road. I know a few colleagues who have had accidents though on cycle paths.

Follow up: Do you know what kind of accidents they were on the cycle path?

Yeah. One of them was because a person walked into the cycle path without looking and the other was because a car turned left, cutting through the cycle path without checking first.

Follow up: Is there anything in particular you do to avoid this happening to you?

All I can do is ride more slowly, and constantly be looking for people who might walk into the lane, or cars that might turn.

Has your bicycle ever been stolen?

Yes, twice. Both times the lock was cut. I carry a bigger lock with me to work now, but it's annoying to carry because it's really heavy.

Between safety and theft prevention, would you prioritise one of these areas over the other if you could improve it? Why?

Either! They're both obstacles to people cycling and I think they're equally important. Anything which helps with theft that isn't just a bigger heavier lock would be amazing, and with safety, if there was something to help stop or detect any upcoming obstacles I think that would be popular.

Interview - Jenna - Commuter + Trailrider

What's the main reason you cycle, and how many times per week do you do so?

I cycle to work because it's better for the environment than driving, but I also cycle with friends through forest trails sometimes on the weekends.

Have you had any accidents cycling?

Loads of times when trail riding! But that's part of why it's fun, and I've never had a really bad accident. For commuting, the most dangerous part for me is riding on the roads when cars overtake me.

Follow up - could you expand on that?

Well cars often don't give me enough space when they pass and get really close, plus sometimes they go way too fast so a tiny mistake from me could mean a crash.

Follow up - would you find it useful to be have a way of knowing when cars are about to overtake, since you don't have mirrors?

Definitely. On quiet roads I can hear them coming, but if it's raining heavily, windy, or a busy road, they can come out of nowhere so that's the most dangerous part I think.

Has your bicycle ever been stolen?

Only once, but now I never leave it outside, it comes into my work building and I leave it inside my apartment.

Between safety and theft prevention, would you prioritise one of these areas over the other if you could improve it? Why?

Definitely safety for me, when I'm trail riding it's in my own hands and that's fine but anything to assist with riding on roads would be awesome.

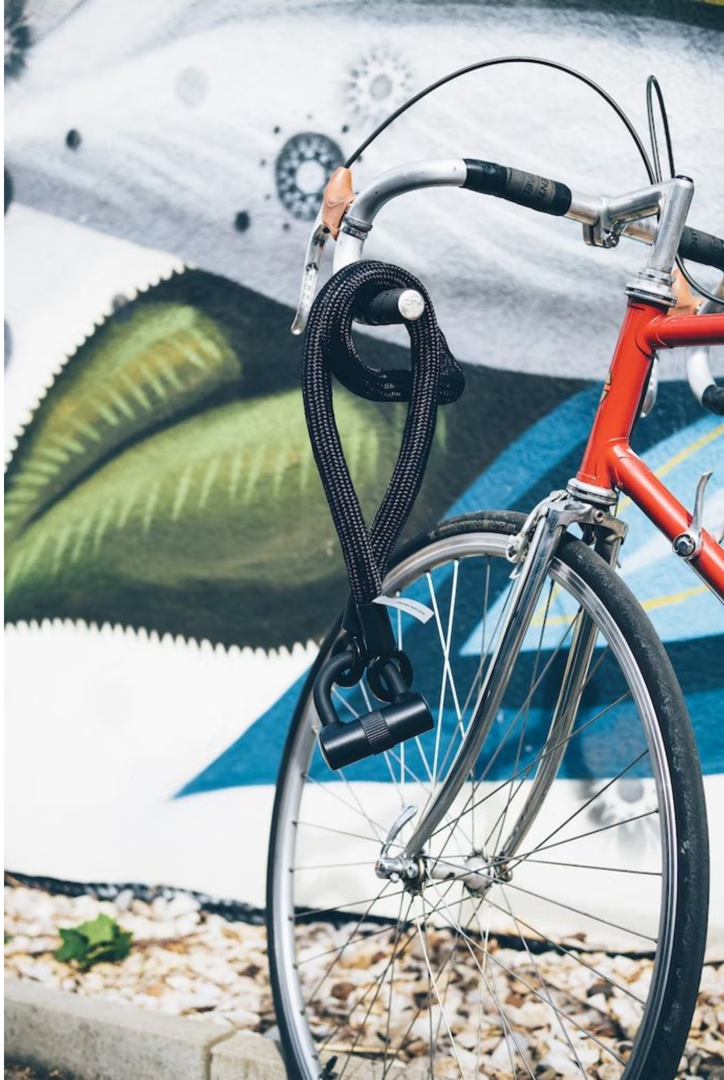
Interviews - Takeaways

From these interviews, we can summarise that **theft** and **safety** can be concerns to both commuters and enthusiasts. Both have had their bicycle stolen at least once, and both have had accidents or close calls.

Between safety and theft, safety was deemed more of a priority (although this is of course a small sample size).

It seems that either of these areas would be suitable to focus on, as any product created would have a sufficient user base for further feedback.

We found that almost all cyclists, commuters and enthusiasts alike, have to cycle on the road at least occasionally, and leaving a bicycle unattended, at risk of theft, is necessary for most cyclists. This allowed us to explore solutions which aimed to improve cyclist safety or theft in some way.



Interviews - Evaluation

We found the interviews to be a very **effective technique** for better understanding our target audience and their needs.

Having a casual conversation without a set of fully structured questions made it easier to gain new insight which wouldn't be possible through a survey, as we could dynamically ask **follow-up questions** to specifically enquire about new areas without having predefined questions.

However, **analysing interview responses is not as easy** as with a survey. Each interview needs to be manually assessed to gather conclusions by recording and reviewing their answers, unlike in a survey where statistics and automatically captured and generated. This makes interviews much more **time-consuming** per answer received than surveys - especially considering that interviews were conducted in-person, whereas surveys were online.

Both surveys and interviews gave invaluable insight into the problem focus stage, and they complimented each other well. Using the **survey responses to refine our semi-structured interview questions** resulted in a very effective approach.

Personas

To **gain an understanding** of our target users, their activities, and the context for the activities they would perform using the end product, we created a set of personas.

We created three different personas (in the next three slides) to reflect different levels of interest in cycling, as people at each level would **value different things**. By grounding personas in the data gathered from questionnaires and interviews, we were able to make these personas **accurate** to real-life users, ensuring our design was **truly user-centred**.

<u>Benefits and what we learned</u>

Creating personas allowed us to better **empathise with the needs** of different users - for example, a social cyclist or commuter is less likely to buy an expensive cycling product, so we knew there was little use in designing a **highly expensive** product for that audience.

Reflecting on the personas also made us realise that despite our research, our solution might still not be as important to real users as we imagined - this encouraged us to conduct **more in-depth interviews** for feedback later in the solution development stage.

Helen Myers - Commuter

Background

Helen lives in Birmingham and commutes to the centre to do her studies. She studies at Birmingham City University and cycles in two days a week. She typically doesn’t cycle outside of the working week and prefers cycling or taking the train in general due to her environmental motivations.

Pain Points

Dislikes having to cycle on the road and not a cycle path
Hates cycling in poor weather conditions

Age: 20

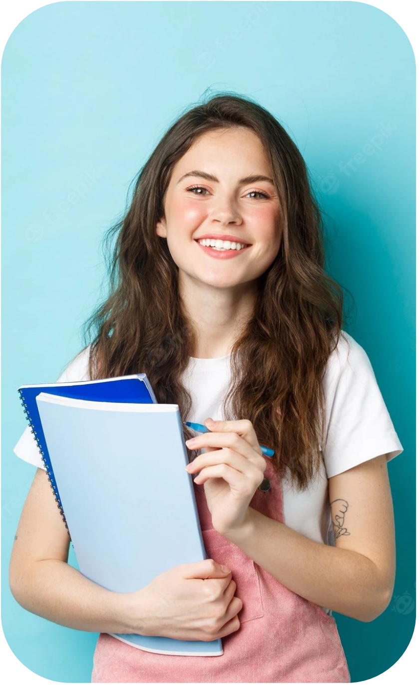
Location: Birmingham

Education: Birmingham City University

Thoughts & Motivations

Helen is an avid commuter cyclist, motivated by financial savings and an interest in helping the environment. She doesn’t cycle socially and doesn’t feel the need to invest in further cycling equipment.

Motivation for Cycling



Daniel Smith - Cycling Enthusiast

Background

Daniel has been an avid cyclist for the past 7 years. He started cycling for fitness, and it turned into a hobby after joining a cycling club and finding people to go mountain biking with. He cycles every weekend and commutes by bike in the summer.

Pain Points

Dislikes cycling on busier roads
Doesn’t like having to carry lock and helmet to work when commuting

Age: 34

Location: Coventry

Education: University Of Warwick

Thoughts & Motivations

Daniel is keen to cycle to work more often to save money on fuel, but isn’t always able to do so. Carrying a helmet, lock and bringing a change of clothes are all obstacles stopping him from cycling more.

Motivation for Cycling

Rick Ainsworth - Social Cyclist

Background

Rick likes to cycle socially with his family and friends. He works from home so doesn't need to commute and normally cycles with his partner and children. He doesn't cycle regularly, and often not on the roads, instead preferring to drive, especially on countryside roads.

Pain Points

Transporting several bikes in one car can be a tricky process
Struggles to find new places to cycle in

Age: 53

Location: Worcester

Education: High School

Thoughts & Motivations

Rick uses cycling mostly for entertainment and socialising, primarily with his family, but also with other colleagues from work, who also live in the suburbs. He is less concerned about safety equipment due to the lack of cars or other obstacles where he prefers to cycle.

Motivation for Cycling

Problem Focus Stage - Summary

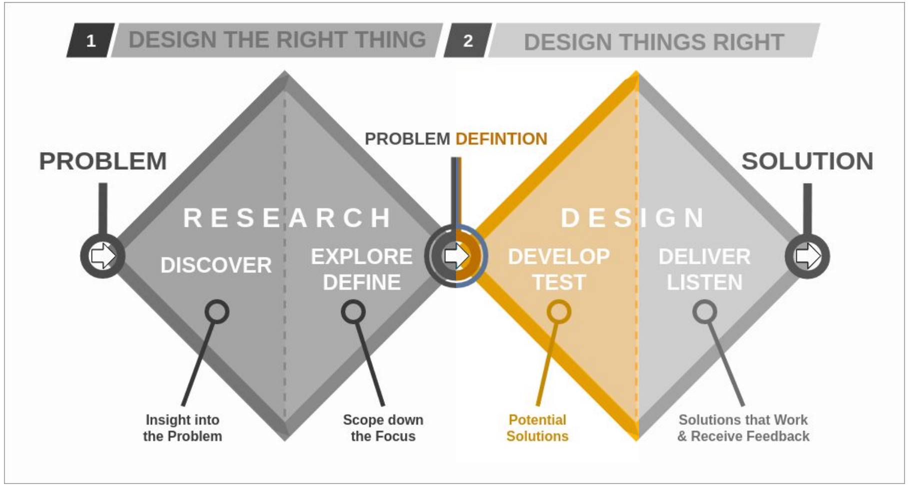
Going into the problem focus stage, we **narrowed down** our problem areas to **bike security** and **cyclist safety**, and the aim of this stage was to gain a deeper insight into the potential issues.

The two-step approach of first conducting semi-structured interviews, and then creating personas using all our research, allowed us to **gain a valuable understanding of our stakeholders**, and how the different issues affect them.

Given more time, we would have **conducted more interviews -** however, from the interviews we did, it seemed our chosen problem focus areas certainly were issues for the interviewees. This was reaffirming and as a result, we will continue with the chosen areas.

With the creation of personas, we have gained a **better understanding of the users** we want to assist, and thanks to the interviews, we are confident that the problem areas we have chosen are important to our stakeholders. As a result, we are ready to move on to the next stage, solution discovery.

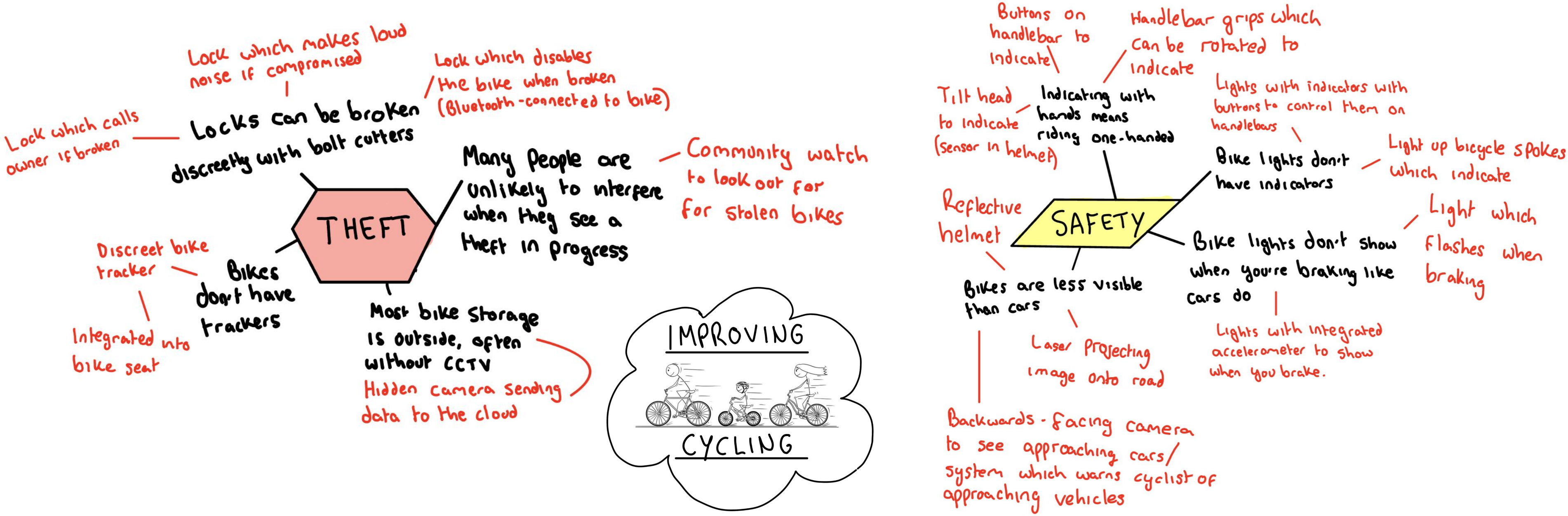
Solution Discovery



Solution Brainstorm Session

Having initially **identified problems** and then conducting our survey and interviews to see areas of interest, we could now begin looking for **potential solutions**.

First, we added to our problem brainstorms with **new problem insights** from the key takeaways of our research and removed the issues which were outside the scope of our focussed problem areas. We then congregated in-person and collaboratively devised potential solutions to some of these issues, allowing us to bounce ideas off one another. This was done as an initial method of finding **potential solutions**, to see if there were any we could investigate further.



Solution Brainstorm Session

Our approach was to look at each problem we noted in the problem brainstorm which concerned one of our chosen focus areas, **safety** or **theft**. We would then come up with ideas as a group to see if we were able to help address the problem.

The solution brainstorming proved effective for us to produce some initial (unrefined) ideas. Similarly to the problem brainstorm session, bouncing ideas off each other was great at encouraging a wide range of ideas, no matter how unusual.

At this stage, we weren't interested in finding a final solution, therefore there was no need to 'rank' these ideas or choose a favourite. The ideas did however prove useful in further steps because in the existing solution research we could see if our ideas were all covered by existing solutions or not.

The session provided us with a great starting point for utilising the six hats approach later on. We had a large number of ideas which we were able to critique through the different lenses of the six hats.

Existing Solutions

We reviewed existing solutions to gain an understanding of how technology has already been used to tackle bike security and cyclist safety.

For each product, we identified positives, limitations and drawbacks and highlighted relevant reviews to better understand the **problems users have with existing products**.

<u>Benefits and what we learned</u>

Reviewing existing products helped us find **gaps in the market** and areas where we could significantly solve problems for cyclists in **ways that haven’t been done**.

Because of the **limited time** available, we only reviewed a few products for each focus area, but if we had more time, we would review a **wider range** of products, especially from less popular sources, to find more **innovative ideas**.

Existing Solutions - Bike Security

Linka Smart Bike Lock

Keyless access lock that can be unlocked through a smartphone via Bluetooth

Positives:
- Offers convenient access to bike
- Battery lasts up to 16 months and is easily charged
- Tamper alert

Drawbacks:
- Bluetooth tracking has a very short range
- Not resistant to rain
- Difficult to mount

★★★☆☆ **Mounting this is impossible without already having holes there**
Reviewed in the United Kingdom on 6 August 2019
Verified Purchase
Everything else apart from the mounting is perfect, however if you can't mount it onto the bike with holes already there them cable ties are pritty much a faff and impossible pointless then it's just another thing to carry around

★☆☆☆☆ **Don't attach to your bike IF YOU THINK YOU'LL EVER BE IN THE RAIN !!**
Reviewed in the United Kingdom on 2 October 2020
Would be customers:

STAY AWAY FROM THIS USELESS PRODUCT !!!!!!

Existing Solutions - Bike Security

Sherlock GPS Tracker

GPS Tracker that hides in bike's handlebars

Positives:
- Discreet
- Offers long-range tracking
- Easy to charge

Drawbacks:
- Can be easily removed from the bike (by thieves)
- Short battery life

★★★☆☆ **Sherlock GPS is a useful tracking device but has some limitations**

Reviewed in the United Kingdom on 19 August 2021

Verified Purchase

The Sherlock tracker works by switching on the GPS locator when you park your bike. Then if its moved, it sends a message and then tracks the bikes location for as long as the battery holds. When you return to your bike you obviously have to remember to switch the tracker off, something I didnt always remember to do!

★★☆☆☆ **Not reliable enough for me to trust**

Reviewed in the United Kingdom on 22 February 2022

I bought a Sherlock as it seems such a brilliant idea. It fitted into the handlebars well and linked with my phone immediately. In the literature the battery life is given as anything from 2 to 7 days. In my case it was 2 days maximum - the battery goes down whether or not the bike is being used. As such it's not the type of product you can set up and forget about. No battery equals no track. While this was my biggest issue I also had a failure between phone and Sherlock. In the end I simply had no faith it would work should the bike be stolen

Existing Solutions - Cyclist Safety

Livall Smart Helmet

Positives:

- Easy to control while riding (handlebar remote and voice control)
- Lightweight and adjustable

Drawbacks:

- Not rain resistant
- Lights can not be seen during the day

Be aware. No rain or water resistance of any sort.

Reviewed in the United Kingdom on 18 June 2021

Verified Purchase

Do not buy this in UK or do not get caught in the rain however the small. Received it on Wednesday and it died on Thursday. Basically if you want to use this in UK, carry another helmet with you in case it rains lol. I got caught in a drizzle on my way back home and helmet died immediately after it started to rain. I assumed this thing will at least be ipx4 but it does not have any water resistance. Waste of money if you buy this for UK. Other features worked nicely until it broke. Sounds is clear but very thin

Existing Solutions - Cyclist Safety

GoPro Helmet Mount

Strap to mount GoPro to the helmet so cyclists can record journey footage

Positives:

- Easy to fit
- Adjustable to different cameras and helmets

Drawbacks:

- Camera not very secure - can easily be damaged in accident
- Unstable mounting resulting in shaky recording
- Only records in one direction

Expensive and not very useful

Reviewed in the United Kingdom on 12 August 2021

Size Name: One Size | Colour Name: Black | Verified Purchase

Let's talk about the price: £20 for a strap and a plastic mount? Should be less than a tenner. Then it's the stability,, it's just not a very secure way of mounting a camera, there's always going to be some movement. But what I found most annoying is the additional weight of having a camera attached to my helmet, so I ditched it and use a handlebar mount instead. So, a waste of money.

Four Stars

Reviewed in the United Kingdom on 30 August 2015

Size Name: One Size | Colour Name: Black | Verified Purchase

not super rock steady but you can get good footage with it.

Existing Solutions - Evaluation

In the area of bike security, digital products mostly take the form of **smart locks** and **trackers**. Locks prevent theft from occurring in the first place but can be very expensive if they have desirable features (**easy access, waterproofing, GPS tracking**). This is where trackers are advantageous, as they can feature long-range tracking without being too expensive. However, many trackers are either not **discreet** or **easy to remove** - which highlighted we could create a tracker that meets these requirements.

In the area of cyclist safety, various forms of smart helmets have been made with features such as **indication, navigation assistance and crash detection**. We noted each of these features as useful ones we could implement in a more sophisticated smart helmet. We also found **video capture** solutions, which opened us up to a new type of solution we hadn't thought of before.

By reviewing existing solutions we were able to **identify design flaws** to avoid and **features users find beneficial** which we could build into our solution. We also found a solution to a problem we had not explored much before (camera attached to a helmet) which ended up being part of our final solution - making this activity incredibly worthwhile.

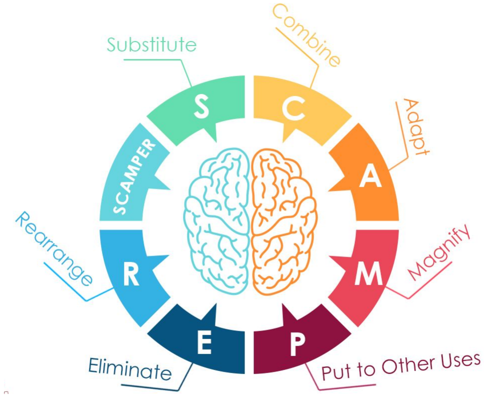
Good artists copy; great artists steal

- Pablo Picasso

SCAMPER Design Activity

SCAMPER is a technique for **generating new ideas** based on existing ones, by asking 7 different types of questions to encourage **creative thinking**.

We applied SCAMPER to the two Cyclist Safety products previously reviewed. Takeaways from the SCAMPER activity can be found on the next page.



Benefits and what we learned

SCAMPER was useful for helping us **think outside of the box**, be more **creative** in our brainstorming and **take advantage of existing solutions** we reviewed.

The most notable idea we took from the activity was that we could **combine useful functions** of multiple products (camera and smart helmet) into a single useful product for cyclists.

SCAMPER would be even more useful if applied to **more examples**, but we decided not to as we had already generated **several good ideas** by this point.

SCAMPER Design Activity

SCAMPER applied to Cyclist Safety Products (Smart Helmet and Helmet Camera Mount)

Substitute

Use accelerometer for automatic brake lights

Combine

Integrate camera into smart helmet

Adapt

Rain resistant helmet (important from survey results + product reviews)

Modify

Lights more visible - perhaps can be reflected off cyclist jacket

Put to Other Use

Use camera helmet not only for recording, but for collision warning

Eliminate

Eliminate camera straps and external camera

Rearrange

Instead of detecting crashes, helmet can be used for preventing crashes

Solution Discovery Stage - Summary

During the solution discovery phase, we were able to **explore a variety of solutions** which were based on the focus areas identified during the problem focus stage.

We were also able to look at a variety of **existing products** to cycling-related problems and utilised customer reviews to identify the strengths and weaknesses of the products.

By utilising the SCAMPER design activity, we were able to analyse the existing solutions to **identify design flaws** to avoid when developing a solution and include **features users find beneficial**.

Ultimately, this stage allowed us to explore, analyse and **learn from a range of cycling products** which will be fed into the solution development stage and help build a successful product.

Solution Discovery Stage - Summary

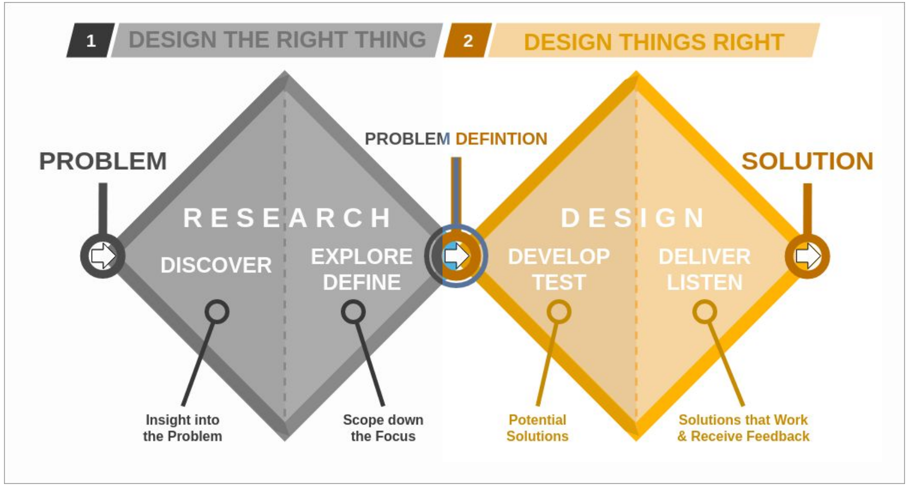
Thanks to solution discovery, we were able to finalise our two problem definitions to find solutions for the next stage.

We elected for both problem definitions (and therefore design concepts) to be concerning the **safety** category, as opposed to theft.

The reasoning behind this was that we didn't believe we could create a digital solution which improves upon those which we found looking through existing solutions. The existing products weren't perfect, but the limitations didn't seem to be design based but rather the technology itself - and we didn't believe this was something we can improve upon.

However, in the safety category, we found some areas which were of interest to explore with design concepts, therefore we focussed our further work on this category.

Solution Exploration



Concept 1 - Problem Definition

Commuters have nothing to help them **indicate to other road users** which direction they're going, resulting in the cyclist using their arms to indicate. This leads to a situation where while approaching a turn, cyclists only have **one hand** on the handlebars. Having to manoeuvre the bicycle to do this with only one hand can **lead to accidents**.

An additional issue to consider is that cars are often overtaking cyclists, and **cyclists can be difficult to spot** on the road, especially at night.

When a cyclist brakes, there's **no way to signal this** to nearby vehicles. Normal rear bike lights don't show that the bike is slowing, providing visibility instead. This can be **dangerous** if a car is tailgating the cyclist and is unaware that the cyclist is slowing down.

In the event that an accident occurs, a cyclist is likely to be seriously impaired and may be **unable to call for help**.

Concept 1 - Requirements

To help **address the problem definition**, prior to developing a solution, we decided to define a set of requirements that the solution should meet. Here are the main requirements addressing the problem solution:

Functional Requirements

1.1) Solution should allow a cyclist to indicate without raising their arm
1.2) Solution should allow other road users to see when the cyclist is braking
1.3) Solution should allow other road users to see when the cyclist is indicating left or right
1.4) Solution should improve cyclist's visibility during day and night
1.5) Solution should make it easier for a cyclist to get help in case of accident

Non-Functional Requirements

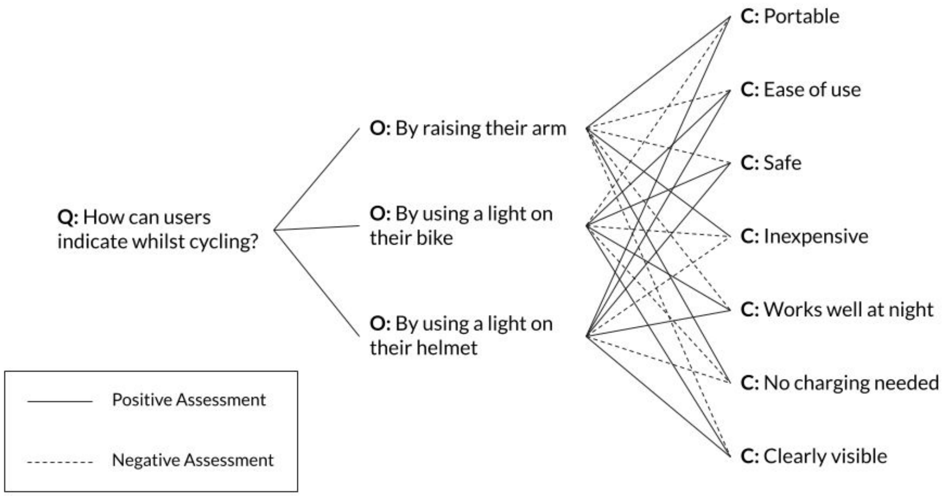
2.1) Solution should be light
2.2) Solution should be able to be used the entirety of a long cycle journey
2.3) Solution should not detract from cyclist's safety

Concept 1 - QOC (Questions, Options, Criteria)

To ensure that our indication design options are **carefully considered** and **weighed up** against each other, we decided to use the QOC design rationale which helps in this process.

This technique helped us to assess the pros and cons of different options, allowing us to select the **most considered** solution.

However, this technique **limited the number of options** and criteria we could consider as the diagram become increasingly difficult to interpret with the number of lines connecting them together. Overall, this design rationale provided a **structured way** of assessing design solutions and was beneficial in developing the design.



Six Hats

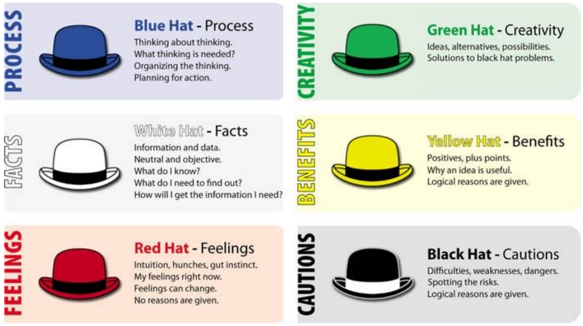
The Six Hats technique allows for practical problem-solving by viewing the problem from a range of perspectives, as shown in the diagram.

We used the Blue Hat to play the conductor of our discussions. The blue hat controlled the thinking and managed the decision-making process between the other hats.

We found the Six Hats approach to be beneficial to us because it made us **step back** from our thinking and address **areas of thinking we had not considered**.

The approach gave us **clear roles** in discussions, which made it easier to **consider all perspectives** before agreeing on an idea.

We found the Black Hat to be less helpful at times when brainstorming ideas as it somewhat limited thinking creatively. It is easy to be **overly critical** and cautious of ideas when **all ideas come with risks**.



Concept 1 - Six Hats Design Activity

<u>**Idea:** Add indicators and brake lights to a helmet</u>

"A helmet with indicators and brake lights has been made before so is certainly achievable."

"Indicators on bikes will make them so much safer before the cyclist can have both hands on the handlebars when they turn!"

"Motorists won't be used to these lights so it would be distracting for them. They would struggle to understand the meaning as the highway code wouldn't cover this."

"Indicators would be really cool at night."

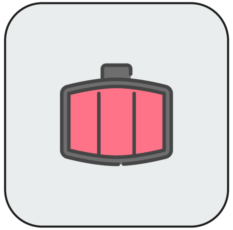
"We could put buttons on the handlebars or give the helmet voice control."

By completing this six hats design activity, we were able to understand different points of view on the concept. The green hat in particular allowed us to be more creative and free-flowing with our ideas and helped us to come up with the voice-activated indication solution.

Concept 1 - Solution (Smart Indicator Helmet)

To help mitigate this important issue with indicating, we propose a helmet with light indication, allowing any indication attempts to be clearly visible. Each of the functional requirements this solution meets is written in brackets. E.g. (req. 1.1)

Features

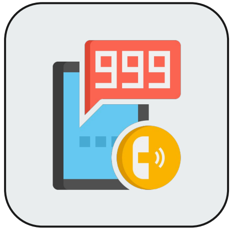


Automatic Brake Light

Alert other road users you are slowing down (req. 1.2)

Night Visibility

Allows you to display your cycling intentions in the dark (req 1.4)



Crash Detection

Automatically call for help in the event of a crash (req. 1.5)

Voice Activated Indicators

Ensures you can keep both hands on the handlebars (req 1.1, 1.3)

LED Underglow

Allows the entire cyclist to be visible (req 1.4)

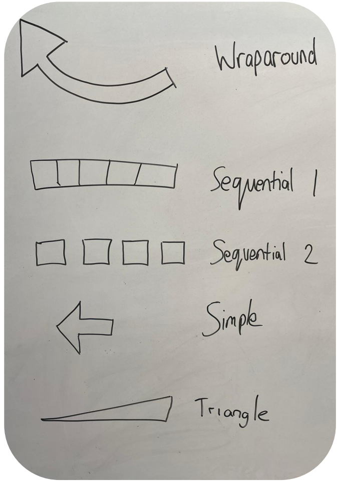
Front Facing Headlight

Allows visibility for the cyclist and oncoming vehicles (req 1.4)

Concept 1 - Initial Sketches

Before choosing specifics for the design, we sketched **rough ideas** for the **different possibilities.** Concept One is our **indicators and brake lights design** with voice detection, and the sketches show different ways in which the features could be implemented.

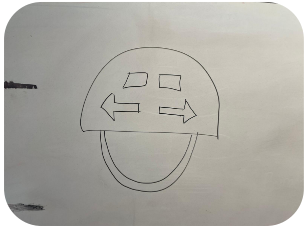
Indicator Shape:



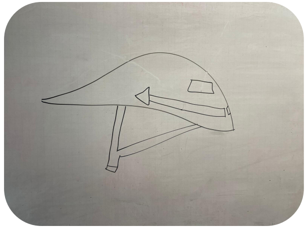
From these options, we elected to go forward with the 'Simple' arrow design. The reasoning behind this is that it is the easiest to understand for other road users as the arrow is a universal symbol, and this design has **few points of failure**.

We also considered 'sequential' designs where the lights would have a pattern, but concluded the extra cost of LEDs and extra points of potential failure would lead to **too much risk** in the design choice. The simple arrow was chosen over the wraparound variant for the same reason of more LEDs leading to more points of failure.

Helmet Shape:



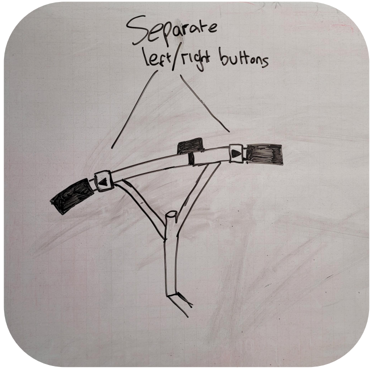
We sketched two shape types to choose from - a 'bucket' style helmet as seen in the first sketch, and then a typical road bicycle helmet shape below.



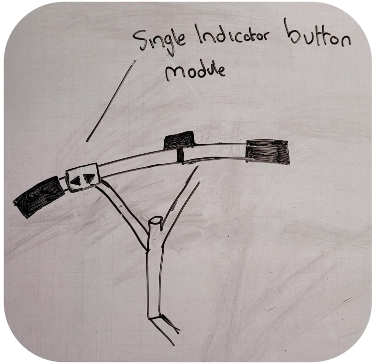
We elected to move forward with the lower design, the road bicycle helmet shape. By choosing a **non disruptive, 'standard'** design, we hope to maximise potential for people to be willing to use the final product.

Handlebar Design

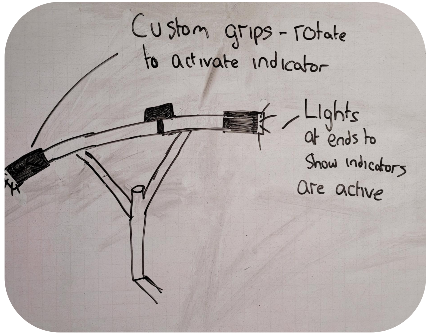
Design One: Two modules, one on each side to control individual indicators with a small speaker to make a noise when they're active.



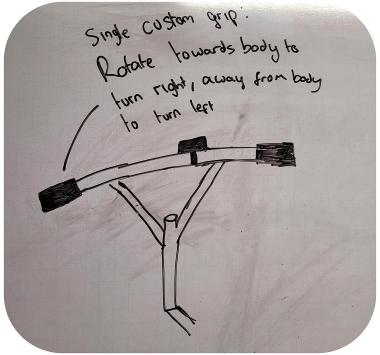
Design Two: The same as design one, but with a single module to control both directions:



Design Three: Custom handlebar grips which are rotated to activate indicators, with lights to show they're active.



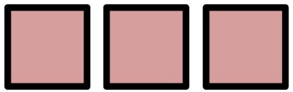
Design Four: Simplified version of design three, but with only one custom grip where the direction of rotation decides which direction to indicate.



From these designs, we chose to go forward with **design two**. Designs three and four would add more cost due to more complicated internals, as well as a higher learning curve and more points of failure. Design two was chosen over design one as motorcycle indicator systems use a system similar to design two, so there is **already precedent** behind its use of it.

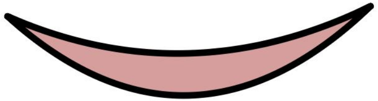
Brake Light Design

Multiple Squares:



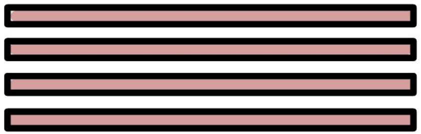
The first potential design choice was the multiple square designs. Each square would be lit by a separate LED. The design is retro - inspired, and multiple LEDs result in lots of illumination.

Wraparound Design:



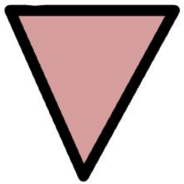
The next design choice is the wraparound design, covering the whole width of the back of the helmet. This design aims to provide bright lighting with only one strip of LEDs needed, in a shape which moulds naturally to the helmet shape.

Burger Design:



The burger design is multiple thin lighting strips stacked in close proximity. This design provides lots of light in a fashionable design, at the cost of lots of LEDs required.

Triangle Design:



The triangle design is the final design we sketched. It consists of one powerful light. The purpose of this design is to minimise the cost by only having one housing for the light, while also providing adequate illumination.

The **triangle design** is the one we chose to move forward with. The reasoning is due to only having to build a **single housing** for the light, as well as the fact that the triangle light will leave **enough space** for the chosen indicator design. We decided that a single light is enough, and multiple lights (seen in the multiple squares and burger designs) are not a necessity, as typical bicycle lights and attachment helmet lights which can be bought only feature a single LED light.

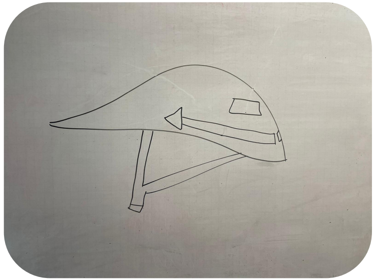
Concept 1 Sketch Takeaways

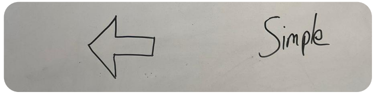
At this point in the process, we had lots of research helping us make informed decisions. All the forms of research covered thus far allowed us to make sketches which could directly address the issue.

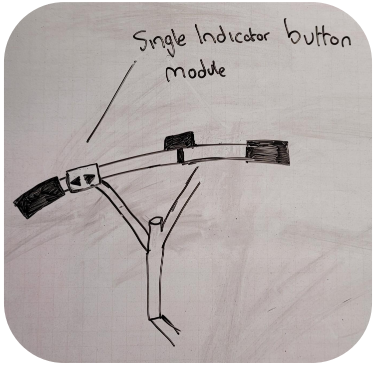
However, in coming up with a final design **many decisions need to be made**, both aesthetic and practical. The sketches were vital in allowing us to **make design decisions** before committing to a first prototype.

Seeing the design options of the potential solution was very useful in **making informed decisions** about what a full prototype could look like. Most design decisions came down to **practicality**, as well as lowering cost and the number of breaking points. While we could potentially have chosen more aesthetically pleasing parts, such as sequential indicators, the helmet is addressing a safety issue and therefore we decided that **making it durable was a priority**.

To select a design variant, we **assessed the designs together** and reached a consensus. Given more time, we would have created more variants and harnessed user feedback to find the most effective design. However, user feedback would be used later on to make improvements regardless.



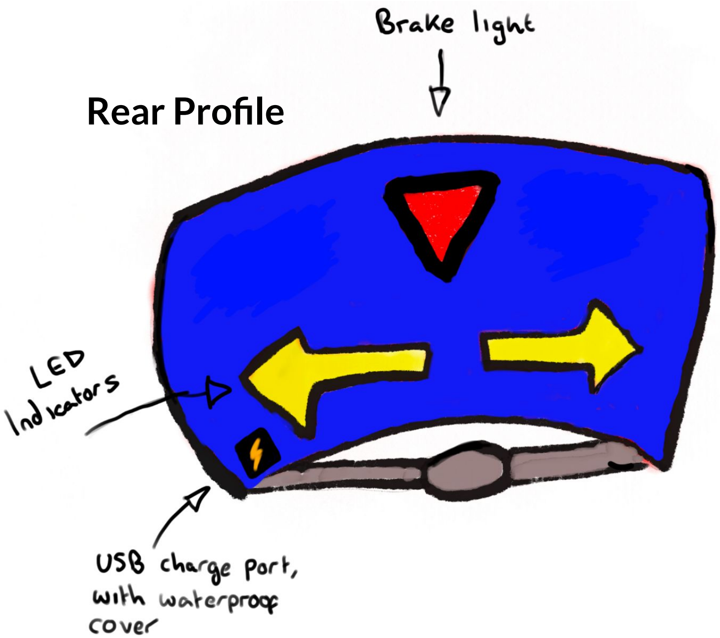




Concept 1 - Full Design Sketch

Side Profile

Rear Profile

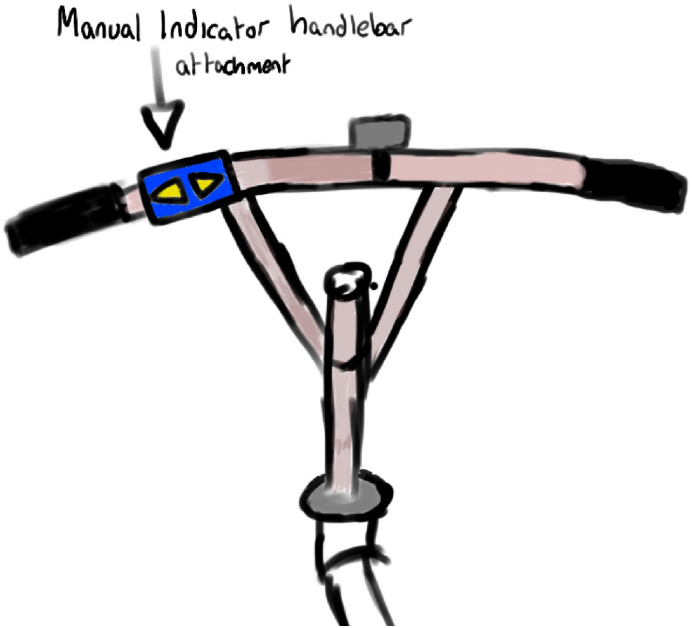


From the side profile, we see that the helmet is a typical tried and tested design. The electrical components are internal for waterproofing.

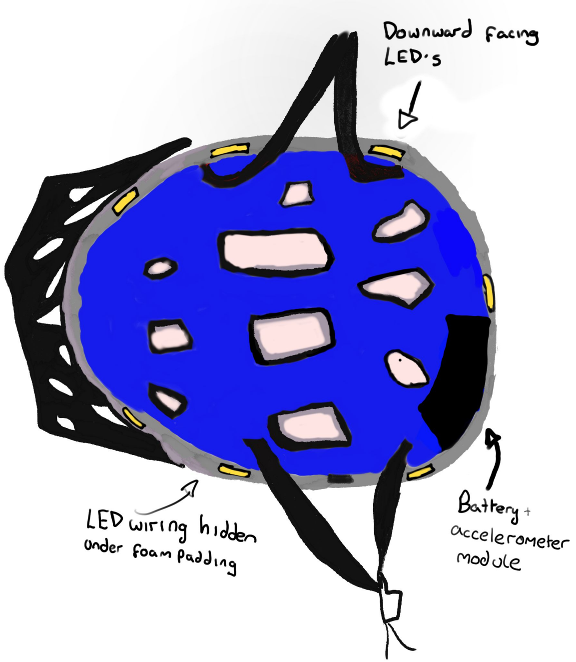
The rear of the helmet includes the brake and indicator lights. The large size of them allows for maximum visibility.

Concept 1 - Full Design Sketch

Indicator Controller Handlebar Attachment



Profile From Below



The view from below shows that this is a very typical helmet. Embedded in the interior of the helmet are the accelerometer and microphone, but no compromises are made with regard to structural integrity.

Concept 1 - User Feedback

The full transcript of our user research can be found within [the appendix]

User Demographics	Sonny	Amy	Tomas
	Cycles: Few times per month Wears helmet: Always	Cycles: Every day Wears helmet: Sometimes	Cycles: Used to cycle regularly Wears helmet: Always

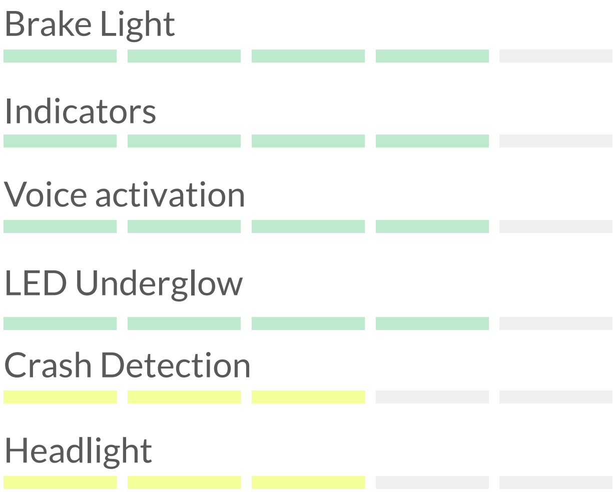
Key Insights

1 out of 3 interviewees **strongly identified with the problem** in the problem definition

1 said they would be **unlikely to buy the product** as they rarely use helmets anyway

1 said they would potentially use it, but were hesitant about the use of voice activation

Average Feature Ratings



Suggested Improvements

- Make the accelerometer as small as possible
- Make it as similar and light as a normal helmet as possible
- Add reflective strips

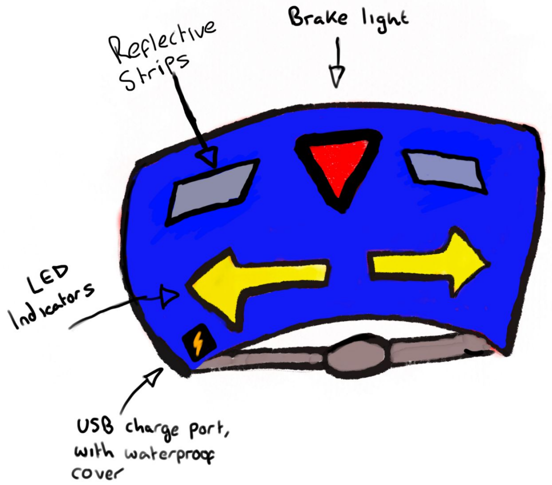
Potential Limitations

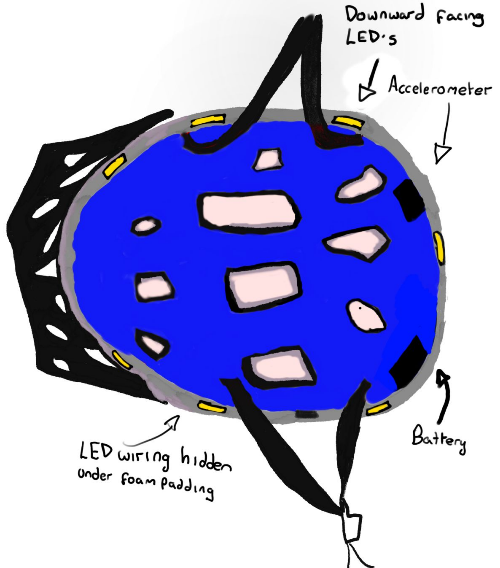
- Heavier than cyclists are used to
- Learning curve for cyclists to adjust to
- Multiple parts which could potentially break

Concept 1 - User Feedback Improvements

There were two main improvement points to take away from the feedback:

- Add reflective strips - This is an easy thing to add to the design which improves safety and makes the helmet seem like a normal, non smart - counterpart.
- Make accelerometer small as possible - We can find the smallest possible accelerometer to use - they can be as small as a 50p coin so it's possible to make it small and light enough to not be an annoyance to the cyclist





Concept 2 - Problem Definition

Cyclists have a **limited field of view -** it can be difficult to look behind when cycling forwards and potentially dangerous. This can lead to cyclists being **unaware of vehicles overtaking** them, which can then lead to **accidents** for cyclists and other road users.

Furthermore, when accidents occur, cyclists often have **insufficient evidence** of the incident, either due to a **limited field of view** in recording or **no recording** at all. This could make cyclists feel **less protected** in case of accidents, which in turn discourages people from cycling.

Concept 2 - Requirements

As with Concept 1, we formulated a set of requirements to address the problem definition:

Functional Requirements

1.1) Solution should improve cyclist's field of view so they don't have to turn around while cycling
1.2) Solution should record the cyclist's surroundings with 360° of coverage
1.3) Solution could warn cyclists of potential collisions
1.4) Solution could feature tracking so it can be easily recovered in case of loss

Non-Functional Requirements

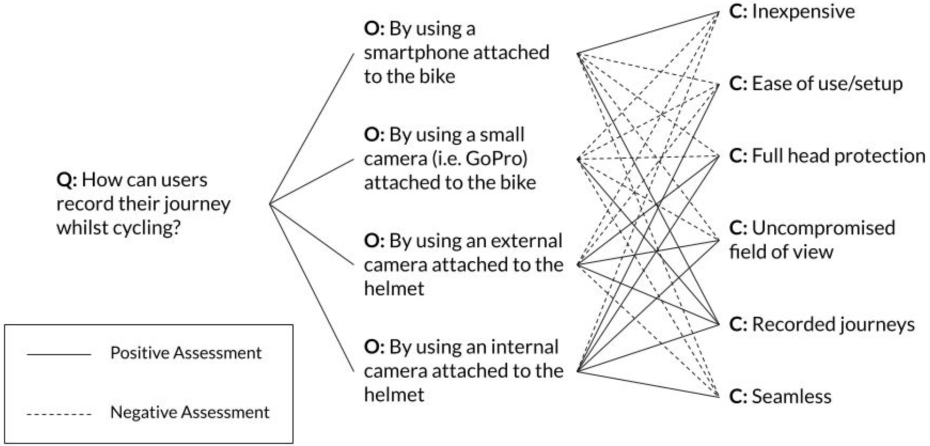
2.1) Solution should be light and easily transported with a bike
2.2) Solution should not detract from cyclist's safety

Concept 2 - QOC (Questions, Options, Criteria)

To ensure that our journey recording design options are carefully considered and weighed up against each other, we decided to use the QOC design rationale which helps in this process.

As previously mentioned, this design technique helped us to assess the pros and cons of different options, allowing us to select the most considered solution.

Ultimately we were able to identify that a helmet with an **internal camera** seemed to meet the most criteria which is why we decided to explore this approach further.



Concept 2 - Six Hats Design Activity

<u>**Idea:** Add a 360° camera to a helmet</u>

"Cameras and sensors already exist for cars, adding them to a helmet should be achievable."

"360° camera helmet will allow for so many other features such as sensors to detect surrounding cars to prevent crashes!"

"A 360° helmet could be dangerous for riders when they crash. The sensors wouldn't be accurate enough to detect cars accurately."

"Think of all of the exciting adventures I can record! I can upload all the videos to YouTube."

"We could add one to the top of the helmet or add cameras around the whole edge."

By completing this six hats design activity, we were able to empathise with different types of users. The red hat in particular allowed us to think of a creative way in which the concept could be used.

Concept 2 - Solution (360˚ Camera Helmet)

To help mitigate this important issue, we propose a helmet with inbuilt cameras, recording a 360 degree field of view around the cyclist. Each of the functional requirements this solution meets is written in brackets. E.g. (req. 1.1)

Features

360° Camera

Ensures every moment is captured (req. 1.2)

Phone Connectivity

Allows you to view a live camera feed and check your surroundings (req 1.1)

Continuous Recording

Records all your cycling sessions, for safety and insurance purposes (req. 1.2)

Collision Warning

Uses AI to detect potential collisions from approaching vehicles (req 1.3)

Crash Detection

Locks current recording to prevent it from being overwritten (req 1.2)

GPS Tracking

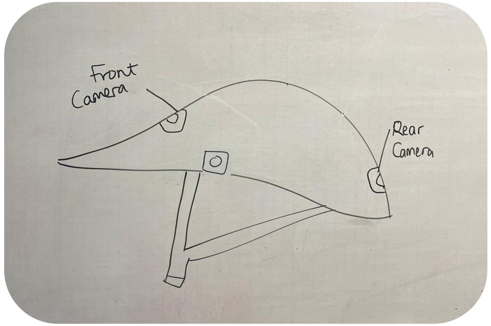
In case of loss and for insurance purposes (req 1.4)

Concept 2 - Initial Sketches

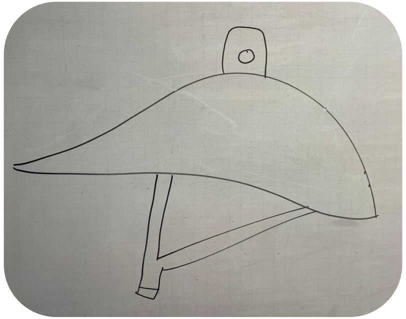
Before choosing specifics for the second design, we sketched some initial ideas of what the product could look like. Concept Two addresses a different problem to the first concept, however, we carried over the choice of helmet shape for this design for the same reasons - we want the final product to be appealing to as wide as possible target audience.

Camera Placement

Option One: The first potential option was four total cameras - this would be enough to cover the full 360 degrees.

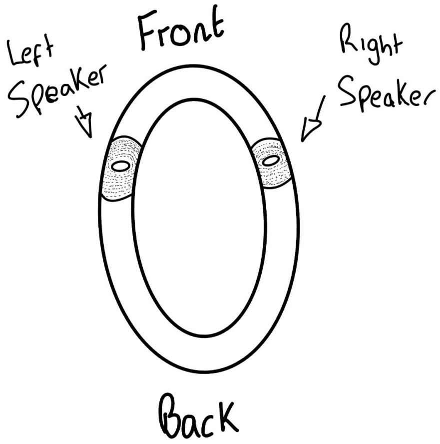


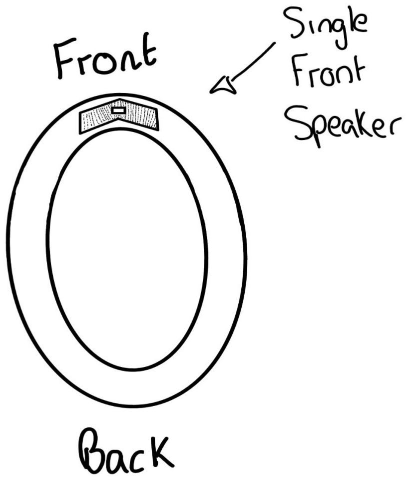
Option Two: The second design sketched was more minimalistic - a very normal-looking helmet, only with a 360 degree camera placed in the centre at the top.



We chose to move forward with **Option One**. The reasoning for this was that the single 360 camera design has to stick out of the top of the helmet, which is not particularly aesthetically pleasing. Along with this, 360 camera technology is expensive, and the cheap options come with heavy compromises. Individual, normal camera lenses reduce cost, and the cameras can be integrated flush with the helmet.

Speaker Sketches





Option Two: The second sketch is for a single speaker, placed at the front. The benefit of this is reduced cost, due to only needing a single speaker.

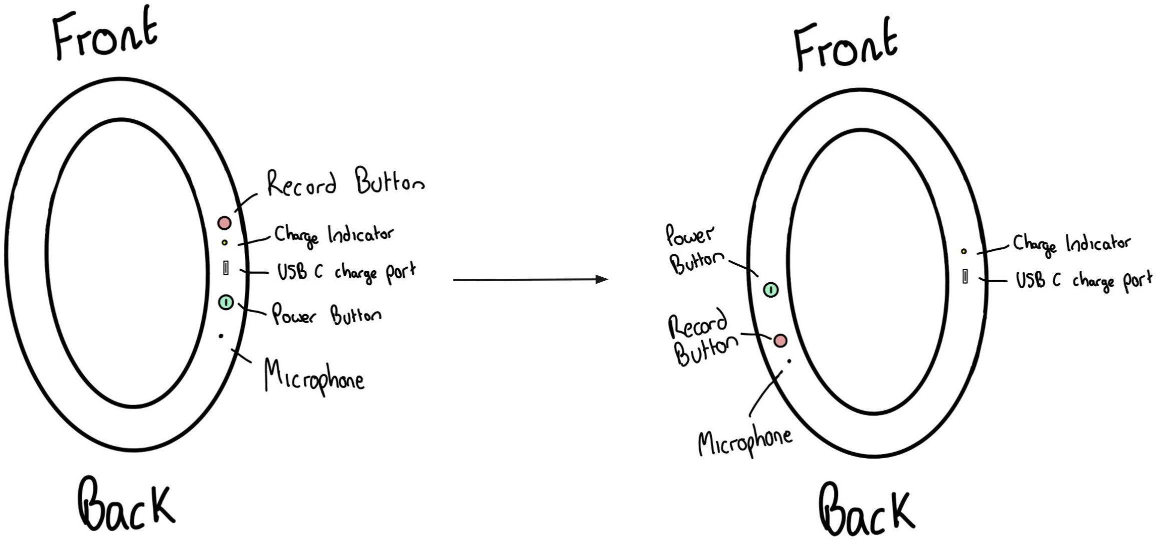
Option One: Our first sketch was two speakers, one for each audio channel. The placement is slightly more forward than the centre, as be most audible to the rider with the helmet being worn.

Option One will be the design we use going forward. The speakers are a vital part of the design, due to the fact that a sound will play when a vehicle approaches, and cycling conditions can be very loud on the road with cars nearby. As headphones aren't a realistic option for safety reasons as cyclists need to hear their surroundings, two speakers placed close to the cyclists' ears forms an ideal solution.

I/O Sketches

Initial sketch: Before sketching, we decided that a downwards facing IO was the way forward. Having the IO inside the helmet means the cyclist can only interact with the helmet when it isn't worn, so that is not an option.

Placing the IO on the outside would make it more vulnerable when crashed, because in a crash, the bottom is very unlikely to be impacted, unlike the outer shell.



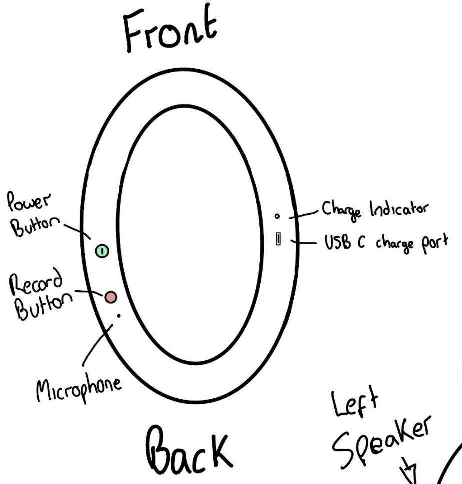
We were pleased with this sketch but decided to move the buttons to the other side of the helmet. This means the buttons aren't surrounded by the indicator and charge port so that the cyclist can more easily find the correct button by feel (a cyclist won't be able to see the buttons when wearing the helmet).

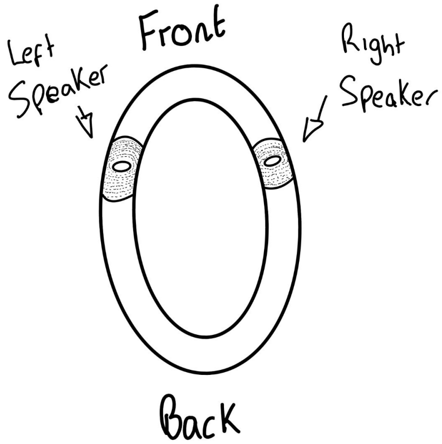
Concept 2 Sketch Takeaways

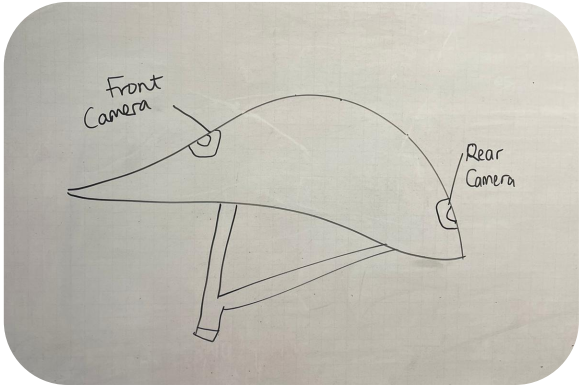
To create these sketches and choose the elements to move forward with, we followed the same process as for concept 1, as this **worked effectively** for us. Again, we were happy with the result.

The initial design choices focus on **practicality** and **usability**, which may be further refined when receiving user feedback after doing the full sketch.

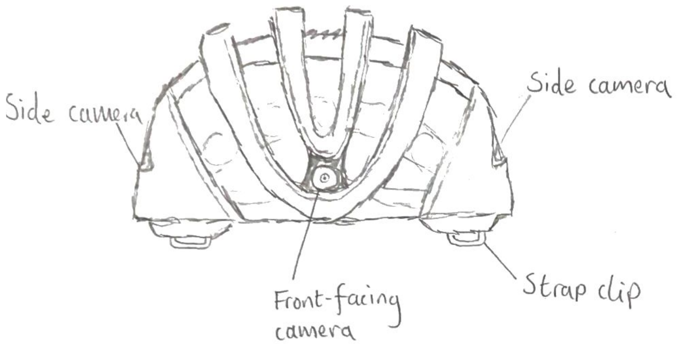
If we were to do this again, we would follow a **similar process** as it was effective and time efficient. Despite lacking user feedback, other stages further on in the process will have feedback so we didn't consider this an issue.



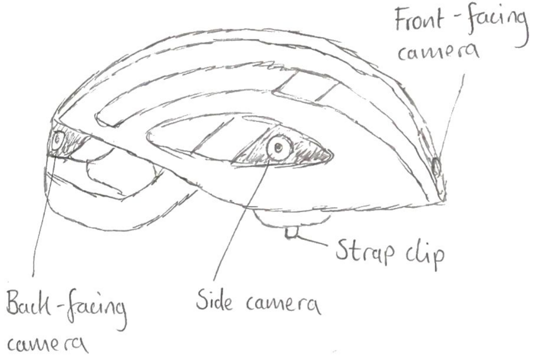




Concept 2 - Full Design Sketch

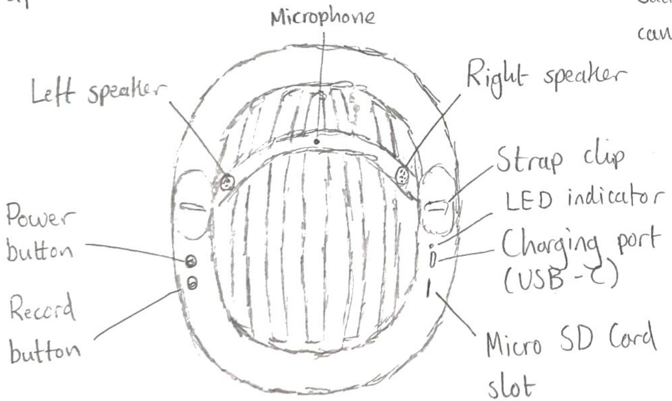


Front View



Side View

Following on from the initial sketches, we sketched the design in full from different angles using the features which we chose to move forward with.



Bottom View

Concept 2 - User Feedback

The full transcript of our user research can be found within [the appendix]

User Demographics

Sonny
Cycles: Few times per month
Wears helmet: Always

Amy
Cycles: Every day
Wears helmet: Sometimes

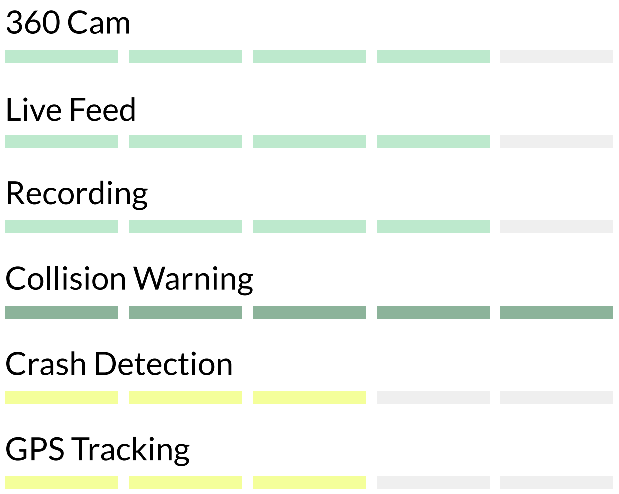
Tomas
Cycles: Used to cycle regularly
Wears helmet: Always

Key Insights

2 out of 3 interviewees **strongly identified with the problem** in the problem definition

2 said they would **use the product -** other 1 not looking to spend money on a helmet

Average Feature Ratings



Suggested Improvements

- Remove SD card (use onboard storage instead)
- Extra padding on the inside
- Camera night vision

Potential Limitations

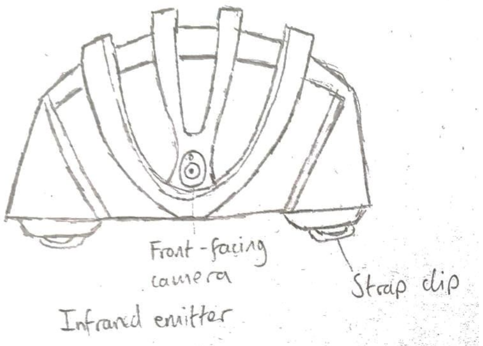
- Not everyone has an SD card reader
- May be heavy
- May have a short battery life

Concept 2 - User Feedback Improvements

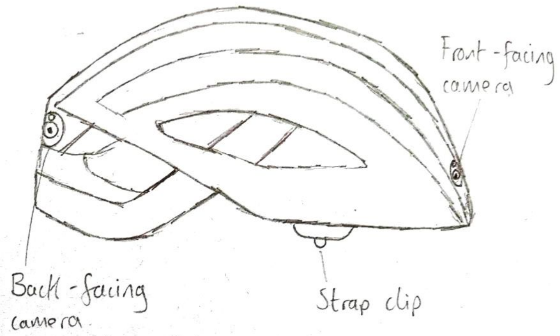
After receiving key insights from our users, we were able to make the following improvements:

- Removing GPS tracking
  - *Feature did not add much value*
  - *Improves battery life*
- Removing the side cameras
  - *Unlikely to capture much action*
  - *Reduces weight and cost*
  - *Improves battery life*
- Replacing the SD card storage system with internal storage
  - *Eliminates the need for users to buy SD cards and card readers*
- Removing crash detection
  - *Feature did not add much value*
  - *Reduces product complexity*
- Adding extra padding to the insides of the helmet
  - *Improves user comfort*
- Adding infrared emitters
  - *Allows the cameras to be used at night or in the dark*

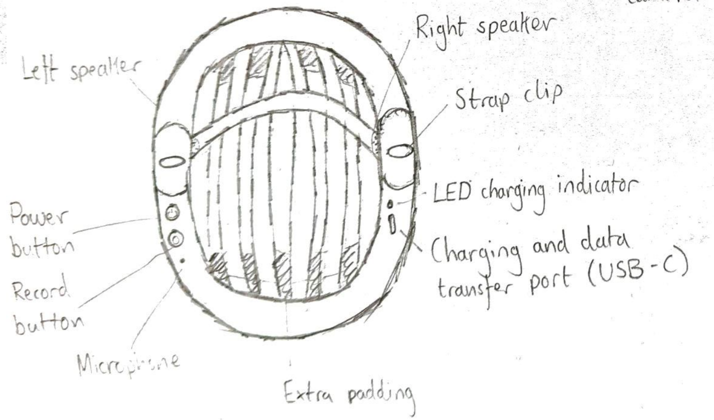
Concept 2 - Sketch #2



Front View



Side View



Bottom View

Solution Exploration Stage - Summary

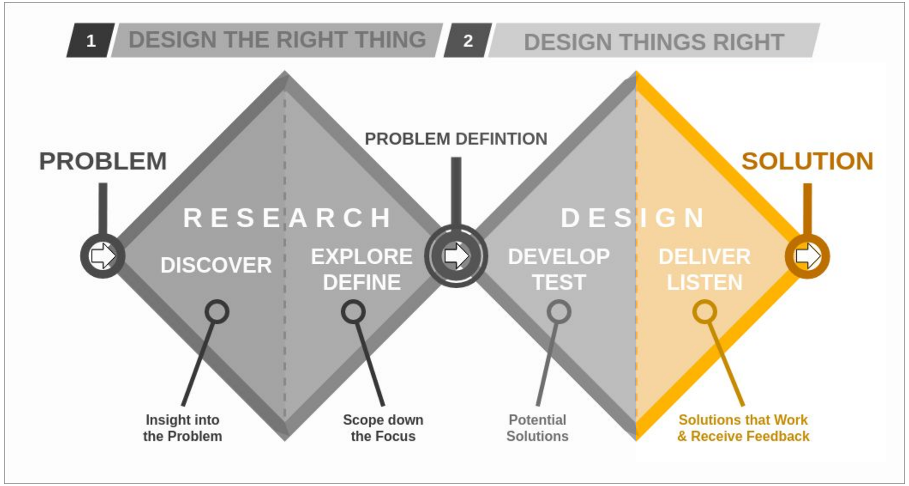
During the solution exploration phase, we were able to **define and develop potential solutions** for two cycling-related problems.

In the first concept, we looked at developing a **helmet with built-in indicators**, making it easier to navigate. In the second concept, we ideated a **smart helmet with front and back cameras** to record journeys and alert them of potential collisions.

To assist us in this process, we used a **variety of techniques** including Six Hats, concept sketches and QOC which guided us in our thinking and development of the solution.

As a result, we were able to develop two refined concepts based on user feedback which will allow us to create our final solution for the design challenge.

Solution Development



Solution - Combining Concepts

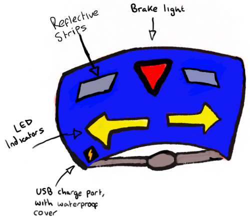
After reviewing the user feedback on both of our concepts, there was a **clear preference towards the second concept**, particularly due to the collision warning system. This would solve a particularly problematic issue amongst our users.

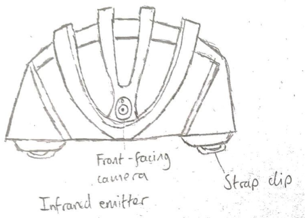
Given that both of our concepts are helmets, we considered combining the features of both concepts into one helmet and even asked our users what they thought of this.

<u>**Combined Concept:** A helmet with inbuilt cameras, continuously recording the cyclist's action, with light underglow and indicators, allowing the cyclist and any direction intentions to be clearly visible.</u>

The response to this was mixed, citing concerns about battery life powering the cameras and lights at the same time. Some of the users were also concerned with the potential cost of a helmet with so many features that it might be a bit heavy and uncomfortable to wear.

Due to this user feedback, we felt it was best to **focus on concept 2**, which also allowed us to direct our attention to delivering quality features which really add value to the product, rather than the number of features.





Solution - Problem Definition

Now that we have decided to pursue the second concept, we have tweaked the problem definition based on some of the comments from our user feedback.

Problem Definition:

When cycling forwards, cyclists have a **limited field of view**, which can make looking behind potentially dangerous. This can lead to cyclists being **unaware of surrounding vehicles**, which can then lead to **accidents**.

In addition to this, when accidents occur, cyclists often have **insufficient evidence** of the incident, either due to a **limited field of view** in recording or **no recording** at all. This can make cyclists feel **less protected** in case of accidents, which in turn discourages people from cycling, especially in **urban environments**.

Solution - Requirements

We tweaked the requirements from Concept 2 based on the latest user feedback and made them more specific to our refined idea:

Functional Requirements

1.1) Solution should improve cyclist's field of view so they don't have to turn around while cycling
1.2) Solution should record a cyclist's surroundings with >270° of coverage
1.3) Solution should warn cyclists of potential collisions
1.4) Solution should be operated by an app via Bluetooth connection
1.5) Solution could prevent recordings from being overwritten in case of collision detection

Non-Functional Requirements

2.1) Solution should weigh less than 300g
2.2) Solution should have a battery life of at least 10 hours
2.3) Solution should be chargeable by a common charging convention
2.2) Solution should not detract from cyclist's safety

Solution - Features

To help mitigate this important issue, we propose a helmet with inbuilt cameras, recording a wide field of view around the cyclist. Each of the functional requirements this solution meets is written in brackets. E.g. (req. 1.1)

Features

Wide FOV Camera

Ensures every moment is captured (req. 1.2)

Phone Connectivity

Allows you to view a live camera feed and check your surroundings (req 1.1, 1.4)

Continuous Recording

Records all your cycling sessions, for safety and insurance purposes (req. 1.2)

Collision Warning

Uses AI to detect potential collisions from approaching vehicles (req 1.3)

Crash Detection

Locks current recording to prevent it from being overwritten (req 1.5)

Speakers

To alert of potential collisions and provide interaction feedback (req 1.3)

Solution - Scenarios

A user scenario describes an action or goal that a user wants to accomplish. They're typically used to describe the behaviour of the user and the product and are a **useful way of examining how the design will work**.

To **demonstrate how our solution may be used** by different types of users, we have created scenarios describing how our different personas could use the product. This is a useful way of showcasing the design and **demonstrating how some of the features work**.

We found that scenarios are an effective way of putting ourselves in the user's shoes, to truly understand their use case and how they might use the product, encouraging empathy. As effective as this technique may be, we found that it is **no substitute for user feedback** which is better at identifying flaws and improvements we had not thought of before.

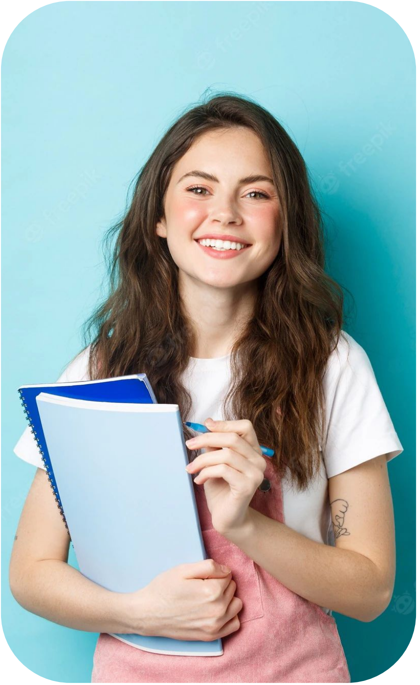
Design is not just what it looks and feels like. Design is how it works.

- Steve Jobs

Solution - Scenario

Helen Myers - Commuter

Helen is a student who commutes to university by bike. She wears Sixth Sense (6S), a smart helmet equipped with front and back cameras that wirelessly connect to her smartphone. The companion app on her phone allows Helen to view a live feed of what the cameras are capturing. This helps her navigate her route to campus more easily and safely, as she is able to see obstacles and other potential hazards in her path. Helen uses the collision warning system in the helmet to help identify cars and pedestrians around her, making it easier for her to avoid collisions and navigate busy streets. Additionally, she can use the companion app to access maps and other navigation tools, helping her to plan the most efficient route to campus and to avoid heavy traffic or road closures.



Solution - Scenario

Daniel Smith - Cycling Enthusiast

Daniel is a cycling enthusiast who loves to explore the country roads near his home. He always wears Sixth Sense (6S), a smart helmet equipped with front and back cameras that continuously record his surroundings as he rides. One day, as Daniel is cycling down a quiet country road, he suddenly notices a car approaching from the opposite direction, on the wrong side of the road. Daniel quickly swerves off the road to avoid a collision, but he is unable to avoid a ditch and falls off his bike. Luckily, Daniel is wearing his helmet and is not seriously injured. However, the cameras on his helmet captured the entire incident, providing clear footage of the car on the wrong side of the road. Daniel is able to use this footage to report the incident to the authorities and to help prevent future accidents on the road.

Solution - Scenario

Rick Ainsworth - Social Cyclist

Rick is a social cyclist who enjoys spending time with his family and exploring the local parks and trails on their bikes. He always wears Sixth Sense (6S) a smart helmet equipped with front and back cameras that continuously record his surroundings as he rides. Rick's children love cycling and are always excited to share their adventures with their friends. To help them do this, Rick regularly uploads footage of their cycling trips to YouTube, allowing his children to share the videos with their friends and to relive their favourite moments. The cameras on Rick's helmet capture stunning footage of the parks and trails, providing a unique and exciting perspective on their adventures. Rick's children are thrilled to be able to share their experiences with their friends, and they look forward to many more fun-filled cycling trips with their dad.

Solution - High-Fidelity Prototype

Following the selection of the concept to refine into a high-fi prototype, we set about identifying several key areas to focus our efforts on to produce a comprehensive prototype across all areas of the product:

1. **Wireframes**
   - Wireframes allow us to identify the user's actions and the flow they will take using the mobile application, allowing us to iterate on layout designs and get feedback from stakeholders

2. **Physical Prototype**
   - A physical prototype gives us the ability to produce a realistic but non-functional end product to evaluate the physical design that a user would end up interacting with

3. **Software Architecture / Hardware**
   - Understanding the architecture and hardware enables the rest of development to be streamlined by taking these elements of the development process into consideration now

4. **High-Fidelity Design**
   - A high-fidelity design gives a much better idea of the final product which would end up in users' hands, incorporating all of the previous elements

Prototype - Wireframes

To give an indication of what the companion app for the helmet would look like, we designed conceptual low-fi designs of the user interface (UI). This allows users to **understand how the application would work** and what it may look like.

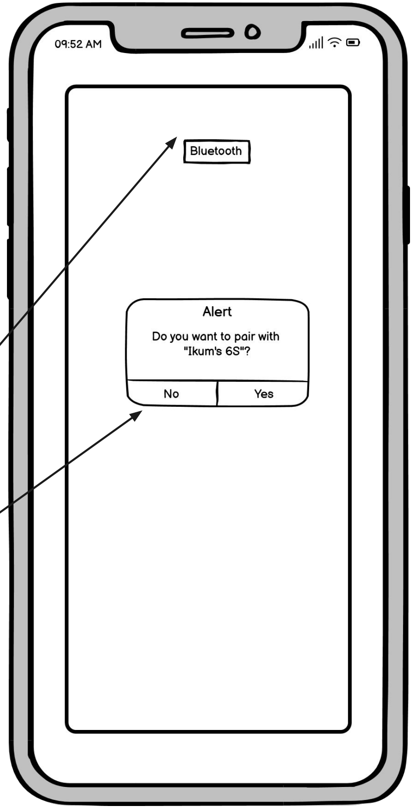
Wireframing enables different UI pages to be conceptualised by laying out the core interface elements. We settled on using low-fi wireframes because they were more appropriate for this stage of the design process, and **enabled rapid iteration of the design** dependent on both team and user feedback.

We did **two key iterations**; before and after user feedback. Both sets of wireframes are annotated with a description to illustrate which component or part of the user flow they belong to.

The wireframes were developed using **Balsamiq software**. We found Balsamiq software to be very easy to use and quick to develop the Wireframes. However, by its design, Balsamiq is limited in creating fully interactive and attractive prototypes like Figma is able to do. Given that we are just aiming to create a prototype, we felt this was not currently needed and that we could achieve our goals in Balsamiq.

Prototype - Wireframes (Version 1)

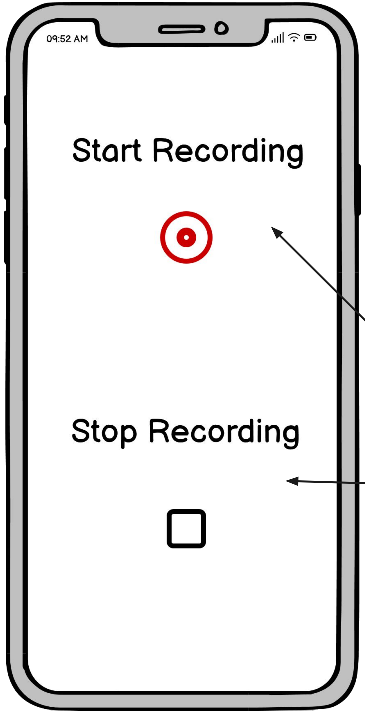
Splash screen - Initial loading screen



Page to allow the user to connect to the helmet

Confirmation box - ensures user connects to correct device

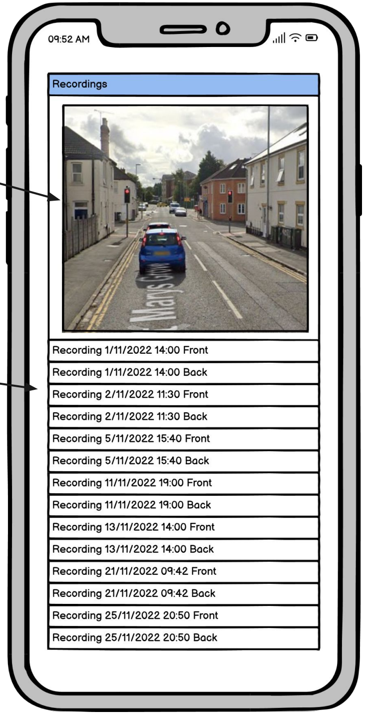
Prototype - Wireframes (Version 1)



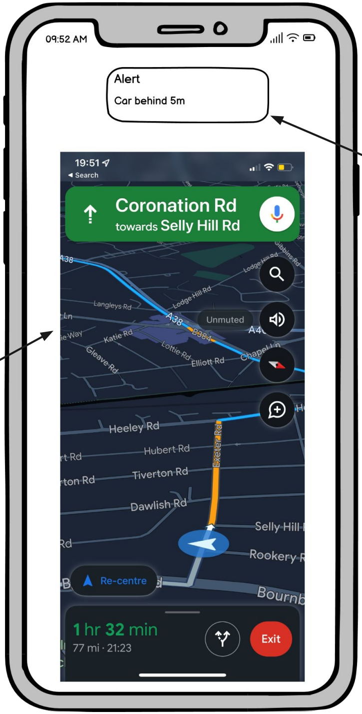
Start and stop recordings - large text and icons to improve readability

Thumbnail of recording

Select previous recording



Prototype - Wireframes (Version 1)



Google **Maps** integration

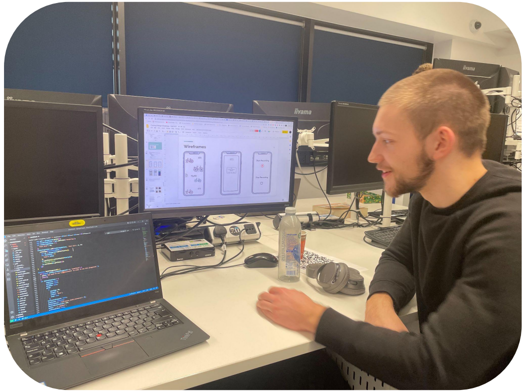
Distance to car behind

Front camera **live feed**

Rear camera **live feed**

Prototype - UI Feedback

User feedback is a way of **collecting user insights** from potential users in order to improve the overall design and functionality of an app. To do this, we asked a few users to interact with the prototype and share their **honest views** on its functionality and design.



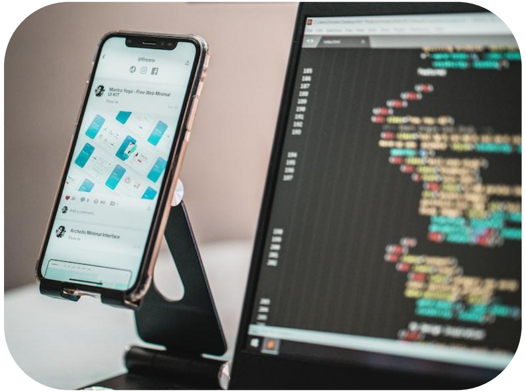
This process allows us to better **understand the needs and preferences of users**, and to identify areas of the app that may need improvement. Additionally, this feedback helps us to gauge the overall satisfaction of users and to identify any potential issues or bugs that may need to be addressed. This feedback can be especially valuable for **identifying and fixing problems** that may not have been immediately obvious to us when developing the UI, but may cause frustration or confusion for users.

The primary difficulty we had in usability testing was **finding willing participants** who are representative of the target user group (i.e. cyclists who would use this helmet). It is important to recruit participants who have similar characteristics to the target users to obtain meaningful and accurate insights. We asked multiple people who we knew mainly from the Computer Science Community.

Prototype - UI Improvements

By listening to the user feedback, we were able to produce a **list of improvements** that needed to be made to the prototype and make it easier to use:

- Add some information on the Bluetooth screen to help pair the app with the helmet. E.g. “turn on the helmet, wait for the red light to flash then enable bluetooth to enable pairing”
- The record and stop buttons are on the same page, this can be confusing to some users
- Buttons on the recording page/carousel to show how to get to other pages
- Add labels “front view” / “back view”
- Title on page “Live camera view”
- Recordings to be bigger with a thumbnail
- App navigation buttons
- Alert could be bigger, with an exclamation mark



Prototype - Wireframes (Version 2)

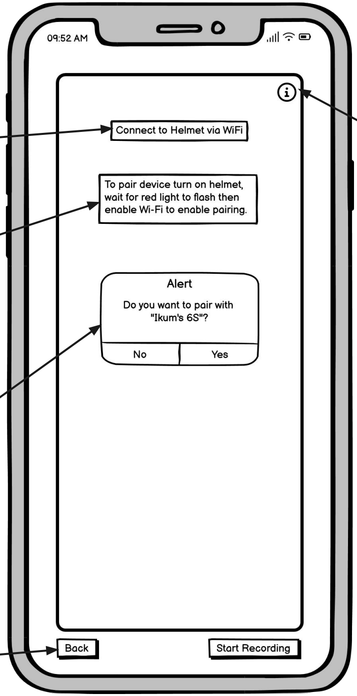
Splash screen - first screen you see when loading app

Connecting via bluetooth - page to connect the helmet to your phone

Pairing instructions

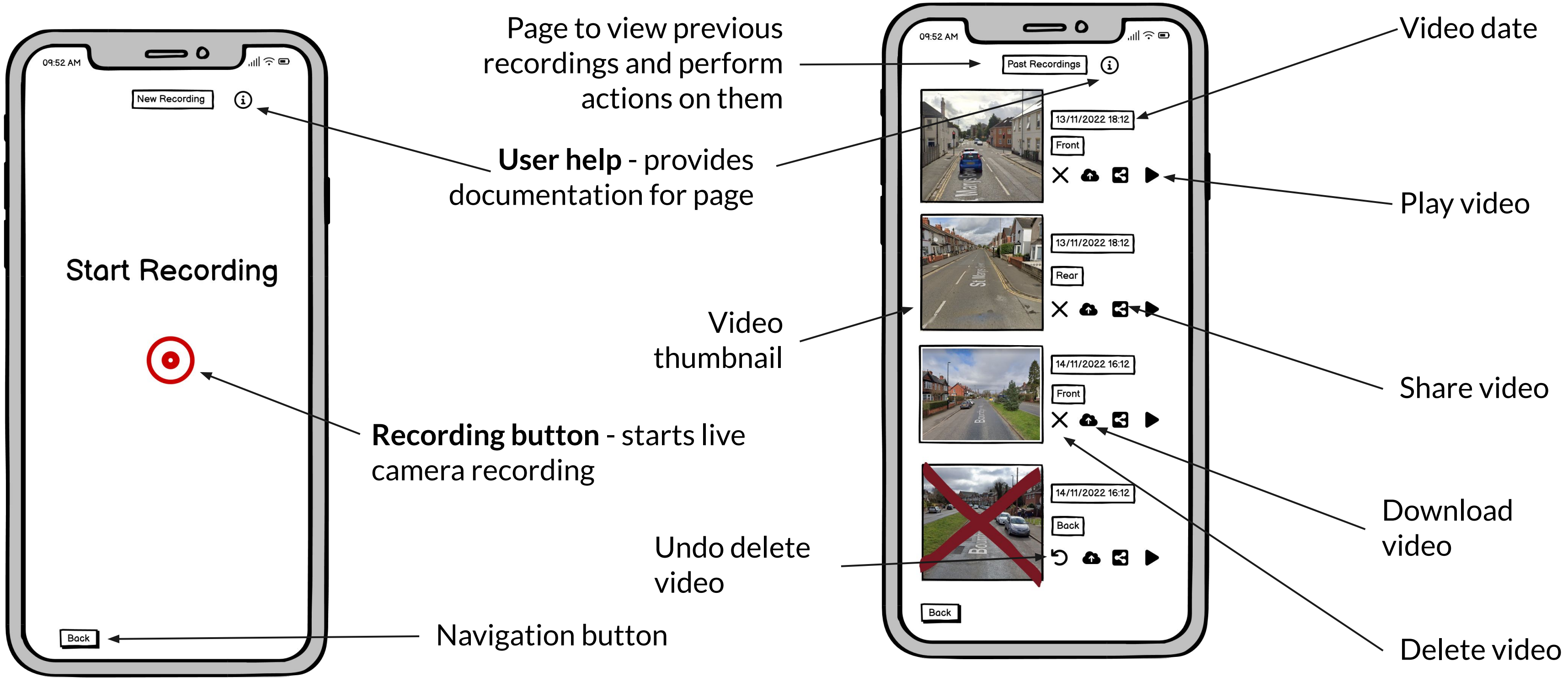
Error Prevention - confirmation of action to minimise chances of user error

Navigation buttons



User help - press this button for documentation on how to connect to helmet via wifi

Prototype - Wireframes (Version 2)

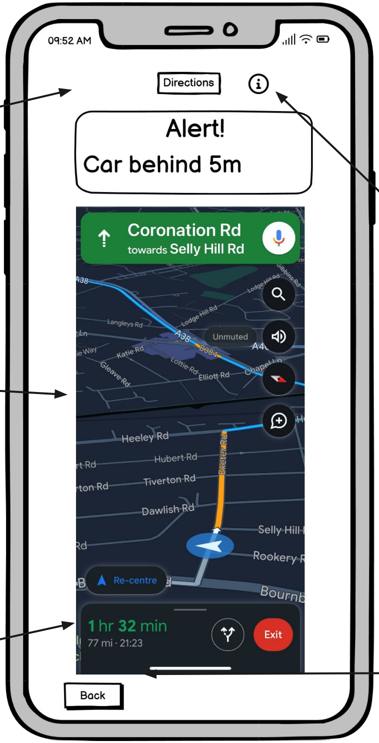


Prototype - Wireframes (Version 2)

Page to show directions to rider while alerting them to nearby cars

Alert showing nearby car

Google Maps displaying directions



User help - provides documentation for page

Navigation

Page to show front and back view camera while riding

Front view

Back view

Stop recording

Wireframe Design Choices

We took into account the following heuristics when designing our wireframes:

- **Visibility of system status** - clear headings for each app section
- **Match between the system and the real world** - simple language throughout
- **User control and freedom** - undo function when deleting the video
- **Consistency and standards** - using an app framework for consistent app design. Used Balsamiq for consist wireframes
- **Recognition rather than recall** - help instructions are available on each page
- **Flexibility and efficiency of use** - start recording feature is easily accessible from start and recordings are ordered latest first
- **Aesthetic and minimalist design** - no irrelevant info included
- **Help users recognize, diagnose, and recover from errors** - error message precisely describes the problem
- **Help and documentation** - help instructions are available on each page

Prototype - Physical

We created a simple physical prototype of the design so we could get **different feedback** from the users interacting with a tangible product.

Unfortunately, we did not have access to a bicycle helmet in the shape that our final product will have, so the prototype used a different shape. That being said, the concept of the lenses on the helmet is no different so the prototype still served its purpose for user testing.

We designed a **semi-structured** feedback framework for users, with interview questions about the appearance, practicality and functionality of the product, to get as much **critical feedback** as possible.

Prototype - Feedback

Feedback on the physical prototype was **generally positive**.

Users appreciated that the helmet doesn't compromise on aspects of a normal bicycle helmet and that the design is as **minimalistic as possible** given the constraints of integrating the technology.

All users said that they would be keen to try the product and would use it regularly if it works as intended.

There were a few suggestions to help improve the concept even further:

- **Easily removable** and **replaceable** batteries (came from inspecting the physical prototype)
- **Cloud backup** of recordings (came from our functionality interview questions)
- **Image stabilization** (came from our functionality interview questions)

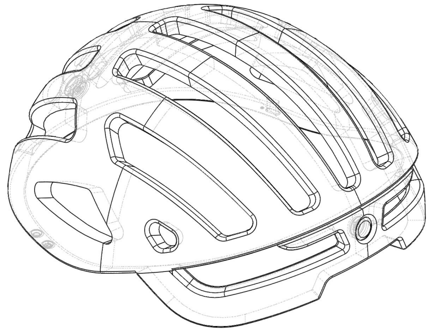
Prototype - Design

As part of producing a high-fidelity prototype of our product concept, we decided to produce a **3D model and rendering** of the product.

The helmet was designed in a 3D CAD software called **SolidWorks** which is widely used in the engineering industry. Due to the curved nature of helmets, they can often be **difficult to model** in parametric-based software and makes use of advanced curve modelling features. It took some time to model the concept consequently and we were unable to add all of the components of the helmet to the design as a result, such as a removable battery which would have added even more complexity to the model.

However, as this is just a prototype we felt it was acceptable to omit this from the design and focus on the main features of the helmet, such as the cameras, buttons and charging port.

Although modelling the helmet in this way was a time-consuming and technical process, we believe it was worth it as we were able to constantly **see what the product looks like** after design tweaks and **view it from different angles quickly and easily**. This helped us understand the user experience and alter the design accordingly if any changes are required.



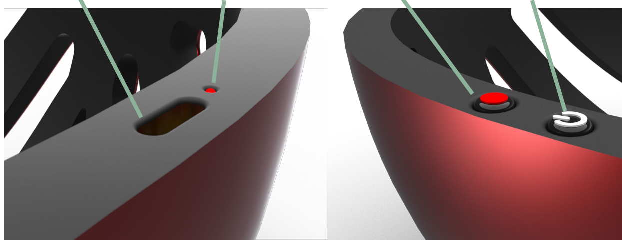
Prototype - Design Rendering

Product rendering allows designers to create **realistic depictions** of a particular product. This way a single product can be shown from different angles, making it easier for the viewer to perceive the object up close and find out how it works.

By utilising the 3D model we designed, we were able to produce a rendering of the product relatively easily, harnessing **SolidWorks Visualise**. This allowed us to explore a variety of colours and materials the product could be made from by the click of a button.

This allowed us to clearly translate our concept into a **virtual model**, helping users **understand its functionality** and what it will look like before it is even manufactured. This will make it particularly easy to market the product with little to no expense and help **get further user feedback** before manufacturing.

However, 3D renderings may not always reflect what materials may look like in real life and is no substitute for a physical prototype that users can interact with and try on.



Prototype - Software Architecture

In this section, we will cover the architecture of the product - the specific technologies to be used, and how they will be linked together.

When designing any software, there are many options to choose from. We made an active effort to choose **well-supported libraries and languages** which have lots of documentation and are still in active development.

By doing so, the software will be more straightforward to bring to life, as there will be lots of available examples and thorough explanations. Also, by choosing popular libraries/ languages in active development, the performance of our software has a chance to improve over time if the performance of the third party libraries is improved.

Prototype - Software Vehicle Detection

One key feature of our product is **vehicle detection** running on the phone, enabling the cyclist to be **aware** of cars passing **too closely** or in their **blind spot**. This will give the user greater protection by increasing their awareness while cycling.

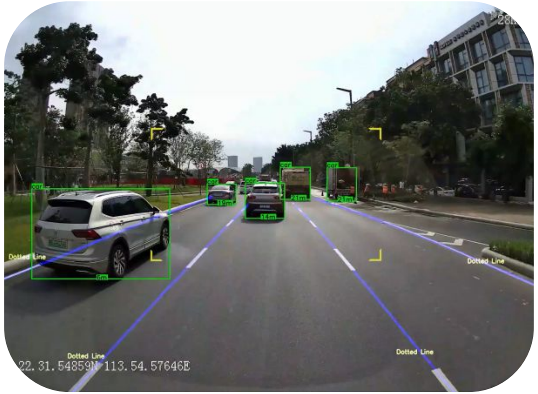
To alert the user, this will give flash an **alert** on their phone - if they choose to have it mounted to their handlebars - and the helmet will play an **audible warning sound**. This will only occur if a car is close by, is sitting within the cyclist's blind spot or is on a collision course, with different sounds depending on the warning type and direction of the collision.

Vehicle detection can take advantage of the cameras located on the product to run real time identification and tracking of vehicles on the roads. This has the added advantage of **not** requiring **additional sensors or hardware**, with all image and vision processing handed off to the user's smartphone rather than running it on the embedded device.

Prototype - Software Vehicle Detection Overview

To detect vehicles which fall within our criteria to alert the cyclist, we are using AI powered real-time vehicle detection, improving their awareness and safety. Vehicle detection will use the well known **‘YOLO’ algorithm** for real time processing, with **Tensorflow Lite**.

The detection processing will take place on the phone app. Phones are relatively **low powered** so the frames per second that the model can handle will be low. We will feed 24 FPS to the phone app live stream, but the model itself will be limited at 2-4 FPS which is sufficient to detect cars in enough time to alert the cyclist.



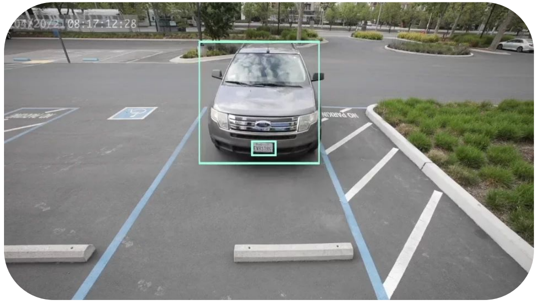

```
conv_layer(self,idx,inputs,filters,size,stride):
    channels = inputs.get_shape()[3]
    weight = tf.Variable(tf.truncated_normal([size,size,int(channels),filters], stddev=0.1))
    biases = tf.Variable(tf.constant(0.1, shape=[filters]))

    pad_size = size//2
    pad_mat = np.array([[0,0],[pad_size,pad_size],[pad_size,pad_size],[0,0]])
    inputs_pad = tf.pad(inputs,pad_mat)

    conv = tf.nn.conv2d(inputs_pad, weight, strides=[1, stride, stride, 1], padding='VALID',name=str(idx)+'_conv')
    conv_biased = tf.add(conv,biases,name=str(idx)+'_conv_biased')
    print('Layer  %d : Type = Conv, Size = %d * %d, Stride = %d, Filters = %d, Input channels = %d' % (idx,size,size,stride,filters
    return tf.maximum(self.alpha*conv_biased,conv_biased,name=str(idx)+'_leaky_relu')

def pooling_layer(self,idx,inputs,size,stride):
    print ('Layer  %d : Type = Pool, Size = %d * %d, Stride = %d' % (idx,size,size,stride))
    return tf.nn.max_pool(inputs, ksize=[1, size, size, 1],strides=[1, stride, stride, 1], padding='SAME',name=str(idx)+'_pool')

def fc_layer(self,idx,inputs,hiddens,flat = False,linear = False):
    input_shape = inputs.get_shape().as_list()
    if flat:
        dim = input_shape[1]*input_shape[2]*input_shape[3]
        inputs_transposed = tf.transpose(inputs,(0,3,1,2))
        inputs_processed = tf.reshape(inputs_transposed, [-1,dim])
```



Prototype - Software Vehicle Detection Implementation

We chose the well researched and mature YOLO algorithm for vehicle detection. This algorithm is a **highly tuned neural network** which can be used for all types of object detection, with our use case involving vehicle detection. YOLO achieves better accuracy as well as performance than traditional methods of detection. **Performance is a key factor** for this project as real time detection on lower powered devices is needed, such as the user’s smartphone.

These images show a simplified view of how YOLO works. The image is split into N grids (image 1). The grids predict bounding box coordinates relative to their cell coordinates, with the probability of the object being in the cell. This leads to many duplicate predictions, seen in the second image. Non maximal suppression is used to offset the issue, resulting in the final predictions in the last image.

YOLO uses convolutional neural networks for predictions, and does predictions in only a **single run through the network**. Predictions are provided with probabilities, which is perfect for this situation as in the app we can tune at what at what confidence level to display warnings to the user through **real world testing**.

Region-Based Convolutional Neural Networks (R-CNNs) are generally considered superior to YOLO when it comes to accuracy, but since we require real time detection, performance is of utmost priority - and in this department, YOLO is far ahead, making it a great choice. [1]

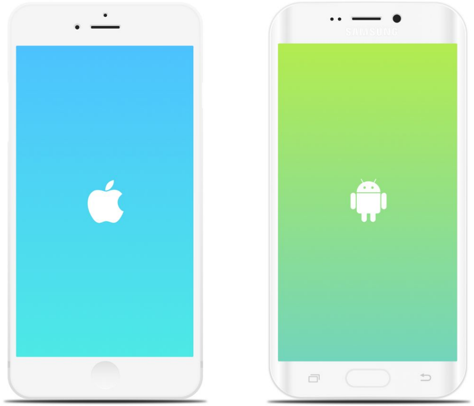
[1]: ‘R-CNN, Fast R-CNN, Faster R-CNN, YOLO — Object Detection Algorithms’ - Rohith Gandhi, towardsdatascience.com

Prototype - App Development

The mobile app itself will be built in **Flutter**. The reasoning behind this, is that the app **only needs to be built once** and will then support both **Android** and **iOS**. The alternative to using Flutter or a similar tool would be to build native apps in Swift and Kotlin, but this would mean having to engineer the same product twice to produce the same result, resulting in twice as much **development** and **maintenance**.

Flutter is one of the most popular frameworks in use currently, and remains in development. There is **lots of documentation**, and there are also **previous examples** of integrating TensorFlow Lite into a Flutter app, making it a perfect candidate.

Flutter has been chosen over React Native or other similar options for performance reasons. While performance doesn't quite match native apps, visual performance isn't a critical requirement of our application and in most cases, Flutter is more performant than React Native, therefore freeing more system resources for the vehicle detection model.



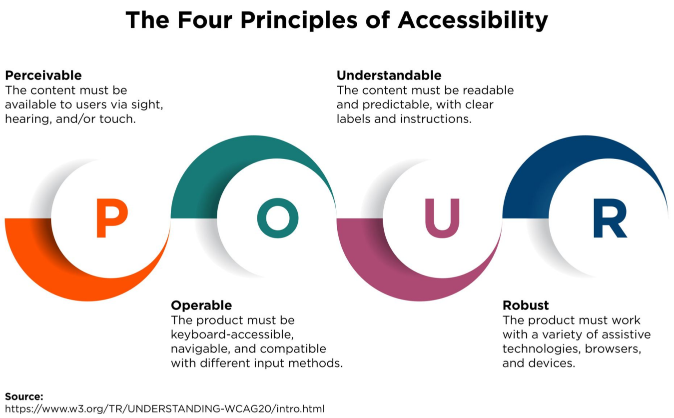
Prototype - App Design

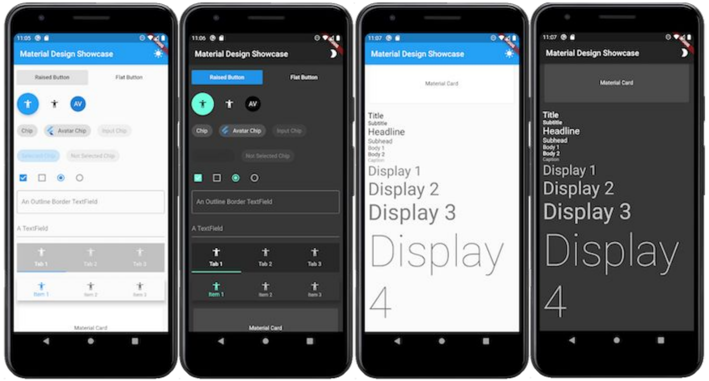
Flutter implements **Material Design.** The app will be using official flutter components/ widgets, which abide by Material Design guidelines. Flutter itself is a Google created framework, so it has full support for Material Design.

These guidelines, created by Google, have a strong **focus on accessibility** [1]. This should allow as far as possible for people with disabilities, eg. visual impairments, to still make use of the app we create.

The app will follow the **WCAG 2.1 AA accessibility standard.** Accessibility involves a wide range of disabilities, including visual, auditory, physical, speech, cognitive, language, learning, and neurological disabilities. The WCAG 2.1 AA guidelines don't cover all of these, but covers as much as is feasibly possible.

[1] Material Design Accessibility: https://m2.material.io/design/usability/accessibility.html#understanding-accessibility



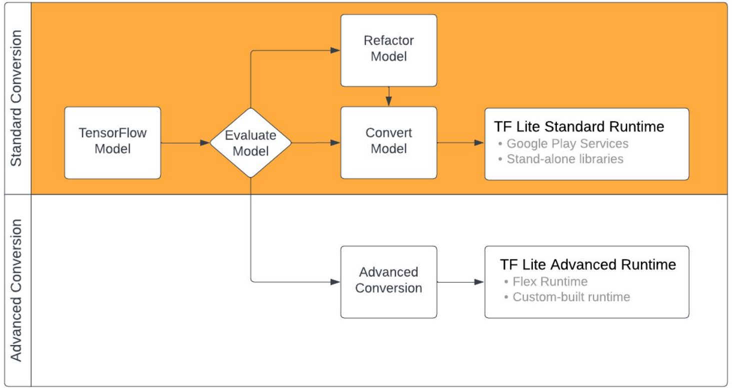


Prototype - App/Model Integration

To perform the vehicle detection, we will be using TensorFlow Lite for maximum mobile performance. This is the current technology on the forefront of mobile AI, providing the best performance through mobile **GPU utilisation**, a **mobile-optimized interpreter** as well as a custom memory allocator to ensure minimal load, initialization, and execution latency (source: TensorFlow.org).

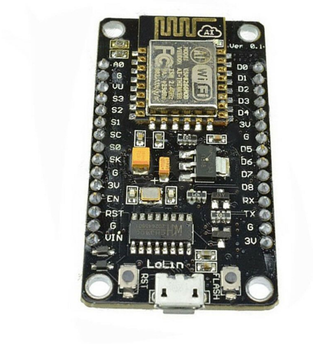
First the trained TensorFlow/Keras model will be converted into a **TensorFlow Lite counterpart**. There is thorough documentation for this on the TensorFlow official website which will be followed.

In Flutter, there is a plugin called **'tflite'** which will be used to integrate the vehicle detection model to the app. There are many examples which show how to do so - here is one which even includes YOLO detection too. Having examples available of how to integrate will make the process far easier as we can follow them.



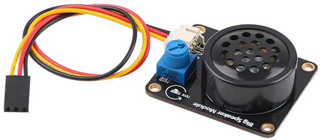
Prototype - Hardware + Connectivity

The helmet will contain two cameras, front and back. The two cameras will be hardwired together with connecting wires running **inside the helmet**. Connectivity to the mobile app will happen via WiFi. Bluetooth does not support the **continuous bandwidth needed** for live video, therefore WiFi is the next logical option. The helmet will create a WiFi network which the mobile app will use to connect to it in the app setup.



This can be performed using small **ESP-type microcontrollers** to undertake the processing. These chips include WiFi, combining the benefits of being lower power and small form factor, enabling it to be integrated into a small object like a helmet easily. The fact that a phone would be in close proximity also reduces the need for an extended antenna. The camera lens is an ESP compatible camera module, which interface with the microcontroller.

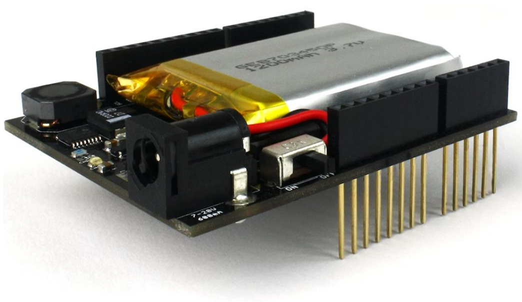
To ensure we can provide audible feedback to the user, we are also including a **pair of speaker modules**, positioned above both ears to provide **immediate feedback to the user**. Like the camera module, this would interface with the microcontroller easily.



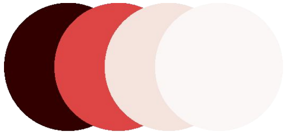
Prototype - Hardware + Connectivity

Finally, with flash storage being **ubiquitous and cheap**, we could use a small amount of flash storage to store media onboard in the event that the connection is not fast enough or the connection is lost. A simple USB-C port will be used for charging due to its ubiquitous nature among end users today and the mandated connector for EU markets.

To ensure that our product is able to be used for extended periods of time, we also need to include **onboard power**. There are a multitude of different **removable rechargeable battery packs** available for ESP-style chips, making it simple to add a portable power source to the hardware. In combination with the USB-C connector, this will ensure that the user has an experience in line with all of their other portable, rechargeable devices, from their phone to bike lights.

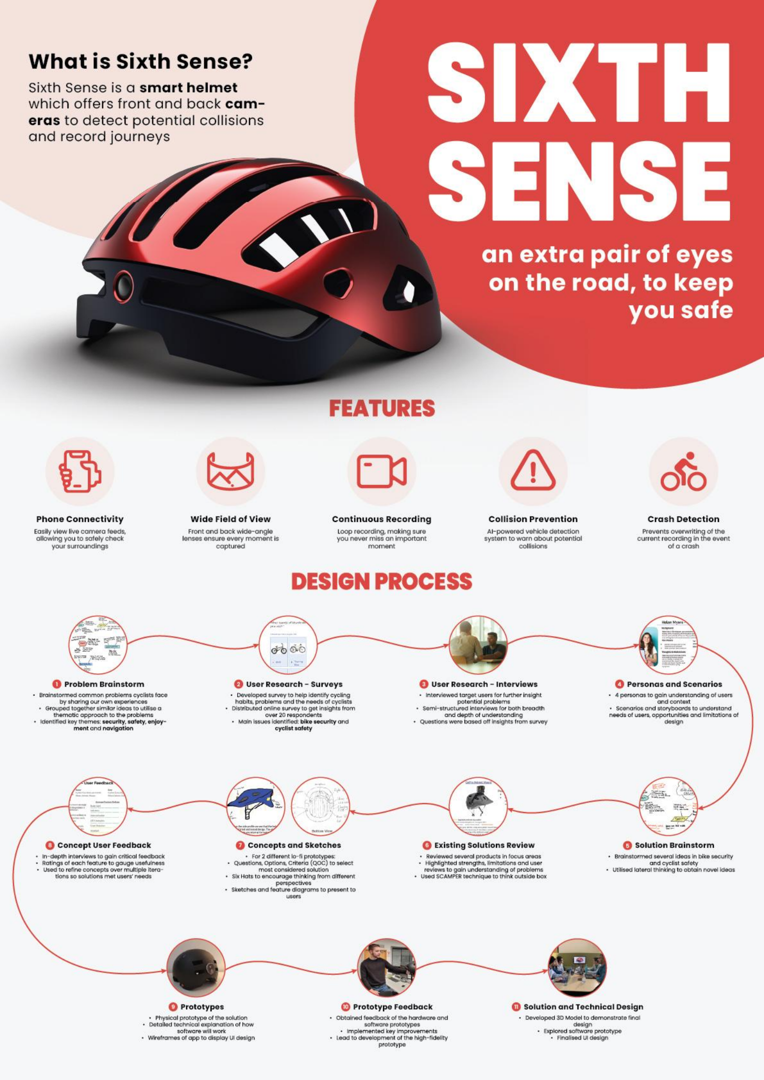


Poster Design



We carefully crafted the poster to ensure it adhered to basic design principles, allowing the content of the poster to make maximum impact. We did this by implementing these principles:

- **Monochromatic** colour scheme
  - Guarantees all of the colours match
- **Neutral colours** black, white and grey used for most background and text
  - Ensures a well balanced poster and there is sufficient contrast making text easy to read
- Use of the colour **red**
  - Considered to be one of the most visible colours on the colour spectrum
  - Only used to help make aspects of the poster stand out
  - Grabs people's attention, helping motorists be aware of the presence of cyclists - thus improving the safety effectiveness of the product
- Use of a **sans serif font** (Poppins)
  - Improves legibility
  - Variety of font weights used to attention to different parts of the poster



Design Challenge - Evaluation

During the design challenge, we closely followed the Double Diamond design process to help guide the development of creating a solution to a problem experienced by cyclist.

We were able to create Sixth Sense (6S), which is a **smart helmet** that offers front and back cameras to **detect potential collisions** and **record journeys**. We believe this solution effectively addresses our problem statement by giving cyclists a wider field of view, recording incidents and alerting the user of approaching vehicles.

Although we feel as if we developed an innovative solution and addressed the brief set in the design challenge, if we were to complete the design challenge again, this is what we would do differently:

- Allow more time to collect responses for the survey and aim to receive **at least 30 responses**
  - The direction in which we took our solution was based off the insights from our survey. By getting more responses we would have had a more representative sample of cyclists and get richer insights.
- Collect survey responses from a more **diverse range of people**
  - Most of our survey respondents were male, ages 18-25. If we had a more diverse group of respondents, the insights would be more representative of all cyclists.
- Aim to **iterate the prototype at least 3 times**
  - We found user feedback on our prototypes valuable for improving our solution, but due to time limitations, we were only able to do it a couple of times. Had we known its value, we would have allowed more time for another round of improvements.

Team Working

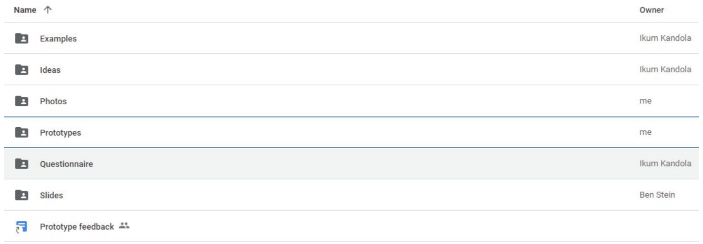
Overall, the team **worked very well together**. Every member of the team **contributed meaningfully** to the group project, and we all were able to collaborate effectively. Given the lack of COVID restrictions for this academic year, we were able to **meet up** frequently **in-person**, enabling us to build important relationships both academically and personally.

Due to the **diverse skills** the members in our group were able to offer, we found that certain individuals were better suited to specific tasks. This made it particularly easy to **delegate tasks** out and allowed our group to complete our short-term goals more effectively. This helped to **keep the group motivated** and on-task throughout the seven weeks we worked together on the assignment.

For example, the more **creative** members of the group were able to focus on **sketching** concepts and **3D modelling**, whereas the more **technical** members were able to investigate how the final product would operate from a **hardware** and **software** perspective.

Team Working

To organise the team, we adopted an **Agile** approach by **breaking the tasks down** each week to assign them to individual members of the group, to ensure everyone had a **balanced workload**. We also encouraged members of the group to **provide feedback** on each other's work via Google comments, to ensure that we peer-reviewed the progress we were making.



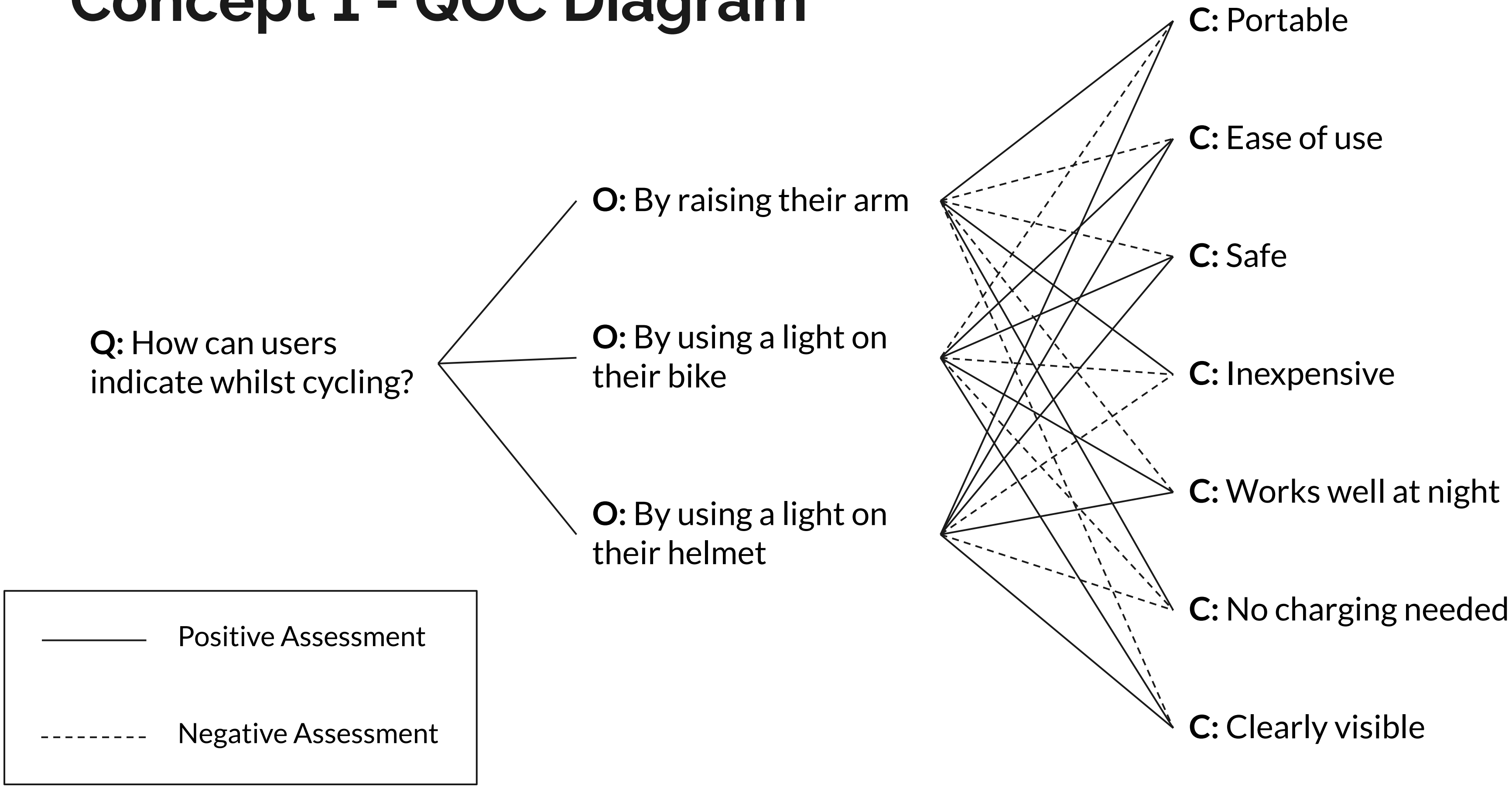
To ensure **progress was monitored** from a group perspective, we met twice a week to feed back the progress each of us had made to the **rest of the group**. This allowed us to **share our thoughts** on each other's work and easily assign tasks to each member of the group.

Working collaboratively meant that we needed to make use of collaborative tools. We used **Google Drive** to store our slide decks, photos, 3D models and other documents. We also used **WhatsApp** to arrange meetings and to discuss issues which arose during the course of the work. Finally, to track progress we also made use of **Trello**, to **assign tasks** to each of the group members, supporting our group's Agile mindset.

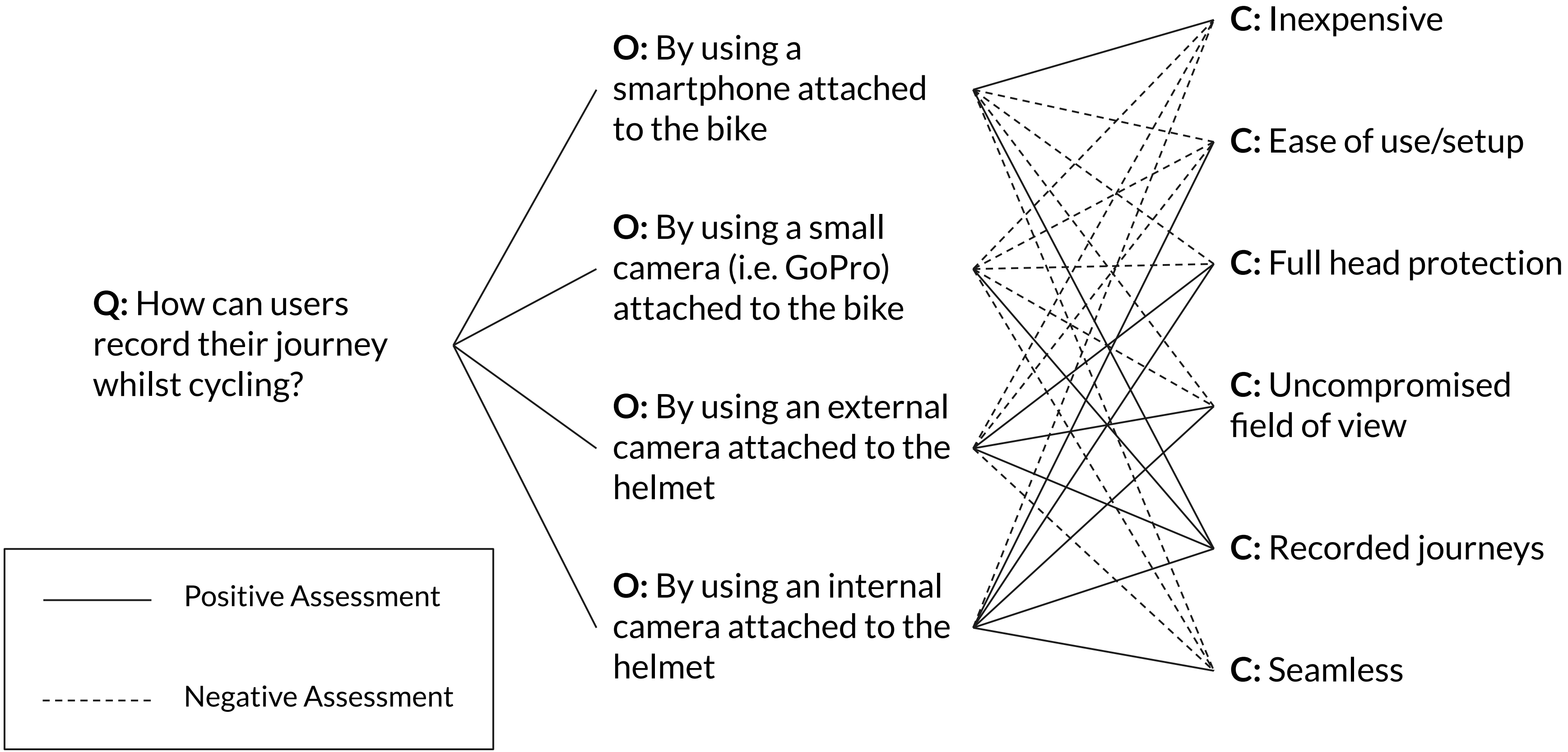
In future, we would endeavour to meet **twice weekly** more **consistently**, as we often had to cancel due to other work from other modules or commitments. Rather than cancelling, it would be **better to rearrange** or - if applicable - **use virtual meeting methods**.

Appendix

Concept 1 - QOC Diagram



Concept 2 - QOC Diagram



Appendix - Concept 1 - User Feedback

Would you use the product? If so, why?

Sonny - Maybe, as long as there is a backup way of indicating. Would be a convenience not to have to use hands. Would make preparing for turns safer as can keep hands on bars.

Amy - No, wouldn't invest in a more expensive helmet since don't always use one anyway.

Tomas - Yes, definitely, for safety (visibility) reasons. Brake lights would be very useful for cars to see me.

Any limitations / can you think of any way to improve the idea/product?

Sonny - No, Make the accelerometer as small as possible

Amy - Yes, cars won't be used to it so they won't understand it. Improvements: Make it look like a normal helmet, make it as light as possible

Tomas - No, Add reflective strips

Appendix - Concept 1 - User Feedback

Do you use voice activated software?

- All three use either Siri or Google Voice Assistant

Would you feel comfortable if your helmet had a microphone and could detect crashes?

Sonny - Yep no issue

Amy - Yes

Tomas - As long as data is not sold or used for any purpose outside of what's needed for it to function

Appendix - Concept 2 - User Feedback

Would you use the product? If so, why?

Sonny - I think I'd use it if it wasn't too heavy and uncomfortable to wear. Would be good to be warned about cars overtaking me before it happens!

Amy - No, I can imagine this would be quite expensive and I wouldn't want invest in an expensive helmet since don't always use one anyway.

Tomas - Yes, I probably would. I'd like to have a recording of my bike rides to view and share highlights with my friends.

Appendix - Concept 2 - User Feedback

Any limitations / can you think of any way to improve the idea/product?

Sonny - I sometimes ride at night, would be good if the cameras can work in the dark as well

Amy - The helmet sounds like it might be heavy with all of those cameras. Maybe some extra padding to reduce discomfort?

Tomas - I don't have an SD card reader in my laptop. Would be good if it could work without needing an SD card.

Do you use a dashcam in your car?

Sonny - I don't currently but am thinking of getting one soon.

Amy - I don't own or use a car.

Tomas - Yes, it was very helpful in a car incident I was involved with!

Appendix - Concept 2 - User Feedback

Would you feel comfortable if your helmet had continuously recording cameras and could detect crashes?

Sonny - Yes

Amy - Yes

Tomas - Once again, as long as data is not sold or used for any purpose outside of what's needed for it to function

Do you record your bike rides with a camera?

All - No