Co-designing interactive systems to increase autonomy and improve the door-to-door customer journey for Irish Rail

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DECLARATION

This thesis is the original work of the author and due reference and acknowledgement has been made, where necessary to the work of others. This work presented in this thesis has not been submitted to any other university or higher education institution, or for any academic award in the South East Technological University. The work reported on in this thesis conforms the requirements of the Ethical Guidelines in Research.

Author: Date:

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Preface:

COVID-19 Pandemic

Please note that this research was conducted during the COVID-19 pandemic. The Republic of Ireland was subject to various social distancing restrictions throughout this period. The research complied with all national regulations and guidelines at every point during the study.

In adhering to the guidelines, some traditional research methods such as in-person interviews, focus groups, and workshops could not operate under these restrictions. Accordingly, there was a need to carry out all research activities remotely, which was somewhat more challenging technically; however, this did not adversely affect the research or the outcomes.

Irish Rail

Please note that this research was conducted with Ireland's national train service provider in mind. The company's official name is Iarnród Éireann (pronounced 'ear-n-rode' 'air-in'), the native Gaelic language version. The English version of the company name Irish Rail is used throughout the report to benefit reviewers and international readers.

Acknowledgement

I would like to express my gratitude to my supervisors Dr P.J. White and Mr. Hilary Dempsey who have both guided and inspired me throughout this study. I would also like to thank my family for their unwavering support. I wish to acknowledge the support from Irish Rail, my colleagues in Irish Rail Information Systems and in South East Technical University DesignCORE.

I am deeply indebted to everyone that participated in the surveys and co-designing workshops for their both their time and valuable insights.

Glossary of Terms

Agile	An iterative approach to project management and software development
METPEX	'Measurement Tool to determine the quality of the Passenger Experience' project (major EU public transport research project)
Modal Switch	Transfer from one form of transport to another
Multi-Modal	Combination of several types of transport in one journey
NDA	National Disability Authority (Ireland)
RTI	Real time information
Scrum	A framework for project management often used in software development
UAT	User Acceptance Testing
WCAG	Web Content Accessibility Guidelines

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Abstract:

Public transport companies like Irish Rail have a vital role to play in countering the many problems that modern society is facing, such as climate change, energy independence while at the same time increasing the mobility of citizens and improving their independence. Accessible, high-quality public transport with low barriers is more likely to be sustainable and potentially contribute to a modal switch whereby private vehicle owners reduce their dependency and increase their utilisation of public transportation (Doyle et al , 2020, Ch. 5). Literature highlights the increased use of technology and digital platforms and the transport and travel industry globally has been quick to embrace new opportunities that these platforms afford. However, even the most cursory look at the selection of smartphone apps provided by the industry shows a focus on the ticketing / commercial / timetabling aspects of their business, overlooking the in-depth needs of public transport travellers. In the absence of deep design research on Irish Rail to determine gaps and unmet customer needs, this research considers these needs in the context of the broadest possible door-to-door journey.

The overall objectives of this research are to inform Irish Rail on new areas for interactive systems for travellers through a user centred design process, learning how to do so and to provide information on how to do this type of design activity in the future. The research questions for this study are as follows

1. What interactive systems should be designed to improve experience and autonomy for Irish Rail's customer's door to door journey?
2. How can user centred design frameworks assist Irish Rail to meet this objective?

To answer these questions the study applies a mixed-methods methodology using qualitative and quantitative data from surveys (N=316) and co-design workshops (4 workshops N=15), following the guidance of Irish Standard I.S. EN 17161:2019 Design for All. The research collects deep insights into the mindsets and needs of Irish Rail travellers to show the potential to improve the door to the door customer journey. Interpreting and analysing these needs, emerging outcomes vis-à-vis the complex stakeholder relationship are reviewed, to parse out the results related to Irish Rail in the context of information technology. The research concludes

that travellers' autonomy and the sense of freedom they experience can be improved, particularly if their needs across the complete door-to-door customer are supported in the areas of information accuracy, personal safety and general accessibility.

The study proposes a high-level conceptual model for a new digital assistant for travellers supporting most of their needs throughout the door-to-door journey which Irish Rail will consider in their technology roadmap for 2022 to 2025. This model and several data visualisations showing the general findings from this research and recommendations for further research will be provided to Irish Rail.

The process of user-centred design and 'co-designing' has successfully yielded many positive outcomes in this study. This method of 'designing with, not for customers' is a method that Irish Rail can and should adopt. This study provides a Design Guide for the company and summarises many of the lessons learned throughout the study to communicate the need for improved user-centred design and further design research by Irish Rail.

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Chapter 1: Introduction

As the Republic of Ireland's national railway operator, Irish Rail traces a long history back to the early 1830s under different company names such as Great Southern and Western Railways and Córas Iompair Éireann (CIÉ, 2022). Irish Rail operates freight and passenger services to over 140 stations and carried in excess of 50 million passengers per annum before the pandemic (Irish Rail, 2022). As a company with a strong customer focus, Irish Rail is keen to maximise its customer base and provide a sustainable alternative to road transport. This study examines the customer journey for Irish Rail travellers, looking to see if it could be possible, through the use of information technology, to improve their experience and to see if there is the potential to increase the travellers' autonomy. By improving this experience, Irish Rail could potentially increase passenger numbers. This research applies equally to other public transport companies as they seek to restore their passenger volumes to pre-pandemic levels. Irish Rail and public transport companies, in general, have primarily focused on ticket sales and timetables via their customer-facing information technology; however, this study takes a broader look at the potential to support customers' more expansive range of needs (DBahn (Germany), 2022; Irish Rail (Ireland), 2022; Renfe (Spain), 2022; SNCF (France), 2022; TfL London Underground (UK), 2022; TrenItalia (Italy), 2022).

As there is an absence of detailed specific research on Irish Rail, the literature review draws upon the public transport industry in general. First of all, the research looks at the concept of the door to door journey. The review considers why improvements can and should be made for travellers and notes both positive impacts of change and negative impacts from failure to do so. Subsequently, there is a comprehensive overview of users' needs and customer satisfaction. The literature review concludes with research on how to approach designing changes to provide for travellers' needs in the future.

The research methodology is documented in Chapter 3 and describes the rationale for using a sequential mixed methods approach for this study and a plan of action research is shown in Fig 1. Also detailed in this chapter are notes on ethical considerations, data management and the researcher's positionality. The chapter concludes with some limitations surrounding this research.

Design practice begins in Chapter 4, with a brief recap of the key points learned via the literature review before describing the initial design of the initial research and the context for opting to use an online survey. The design of the survey questions is shown to be mapped to the customer journey to garner both quantitative and qualitative data. The chapter describes the participants' recruitment and how the survey was subsequently analysed. The design of the second part of the design research, 'co-designing', is then detailed and shows a generative toolkit for interactive workshops with users. Finally, the chapter covers the recruitment of participants and looks at some of the best practices for co-design facilitation.

The results from all design research are detailed throughout Chapter 5, beginning with the main themes arising from the initial online survey. Quantitative and qualitative data from every stage of the door-to-door customer journey is documented, along with commentary and summary findings. Results from the main themes of the co-design workshops, i.e. safety, information, accessibility and autonomy, are also documented and a list of key improvement areas is highlighted. These key improvements are cross-referenced with the stakeholder's remit and the potential for meeting these needs via information technology.

Finally, the research documents numerous gaps in customers' needs, depicting potential solutions via a conceptual design, thematic analysis, customer experience maps and includes a new Design Book for Irish Rail to advocate for a user-centred design culture in the organisation.

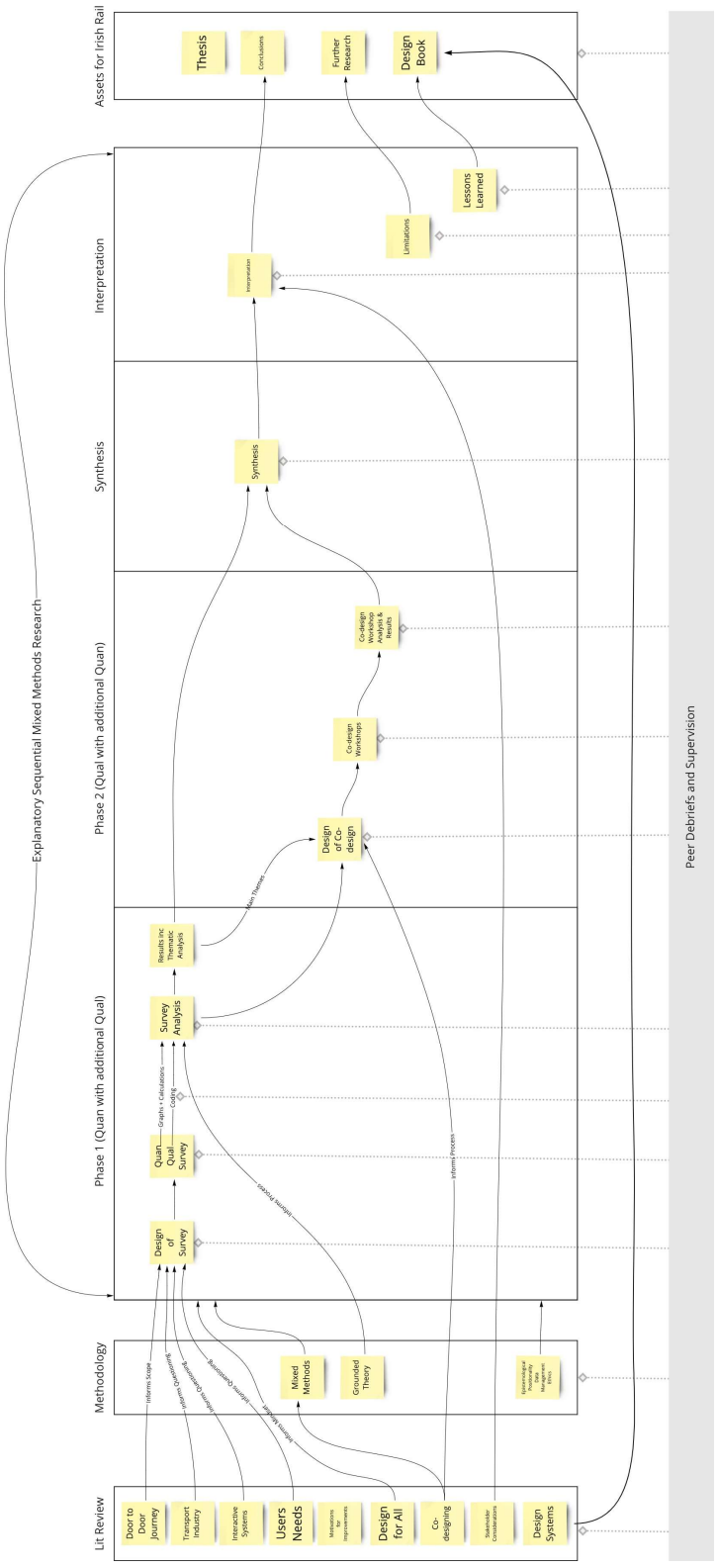


Figure 1: Research Plan (Self-generated)

Chapter 2: Literature Review

2.1 Introduction and sector overview

This literature review is divided into three parts, What, Why and How?;

1. Firstly the research looks at the public transport sector in general, the concept of the door-to-door journey and published research on what the users' needs are for improvements.
2. Secondly, the research looks at why improvements should be made for transport users, from legal reasons to customer satisfaction. It describes instances whereby users experience declines or fails because of gaps in addressing their needs.
3. Finally, the research looks at designing, how public transport companies can find ways under their remit to improve the customer experience through design.

In Europe and across the world, public transport has a vital role in countering problems such as climate change, energy independence and creating accessible and independent societies. Countries face issues caused by transportation and traffic, and each share the problem of how to increase the mobility of inhabitants while keeping pollution, congestion and accidents to a minimum. This mobility has shown to be intrinsically linked to the quality of people's lives and is underscored accordingly via several policy objectives by EU member states. Social and economic policies, sustainable transport, energy and climate change policies are all dependent on the availability of efficient and effective transportation systems (European Commission, 2022).

In most counties, public transport industries are, by the very nature of public sector enterprise, subject to a myriad of governance and oversight through a somewhat complex web of stakeholders. Yet the most straightforward question, 'is public transport a business or a service?' will yield diverse responses. Operating the maximum number of services for the lowest costs would be a typical response to this question (Aecom & Goodbody, 2011). However, they are expected to keep running costs to a minimum, and it would be easy to understand that their travellers' user experience may not be as high a priority as it probably should be.

Success for transportation systems can quite often depend on the level of uptake by the population in the area they operate. This uptake can be influenced by many factors, including

the quality of the passenger experience and the provision of systems that are accessible to everyone. Accessible, high-quality transit systems with low barriers to use are likely to contribute to a modal switch whereby private vehicle owners reduce their dependency and increase their utilisation of public transportation (Doyle et al , 2020, Ch. 5).

This literature review observes the current state of the general public transportation sector to understand its complexity and reveals how the fragmented relationships of the key players may unintentionally hinder improvement. It draws from one of the most prominent peer-reviewed research publications in recent times on public transport via the 'METPEX' project. This '**ME**asurement **T**ool to determine the quality of the **P**assenger **EX**perience' project was a major EU funded public transport research project (circa £3M), involving academics and professionals from over a dozen countries across Europe and coordinated by Coventry University in the UK (Researchers include; Woodcock, Osmond, Tovey, Hrin)

The complete door-to-door journey is examined in detail, looking at users' needs to uncover possible gaps and areas for further research. The case for why improvements should be made for existing and new travellers will then be considered, along with some of the implications of not doing so. Finally, this literature review will look at how and what improvements can be designed from the users' perspective and how companies in this sector, such as Irish Rail, could implement a more user-centred design approach to the implementation of new and improved technology in the future to help retain existing customers and attract new ones in the future.

2.1.1 Door to door Journey

Any simple cursory search through smartphone app stores for public transport apps will show the main emphasis for public transport operators related to commercial transactions, i.e. selling tickets or reservations and providing timetables with real-time updates on the location of services. Table 1 shows a sample of UK and European railway operators high level functionality available in their iOS apps at the time of research.

Table 1: Overview of main features in some UK and European railway operators iOS apps as of May 2022

Train Company	Main Features of Smartphone Apps
Irish Rail	Journey planning (train), Real time information, Ticket prices and sales, Planned Disruption Info
SNCF (France)	Journey planning (multi-modal), Ticket sales, Real time information, Customer Service help.
TfL London Underground (UK)	Journey planning (multi-modal), Real time information, accessibility information inc. lifts, Platform information, Quiet/Busy indicator
Renfe (Spain)	Journey planning (train), mobile tickets, Real time information, Loyalty card, Buy and amend booking.
DBahn (Germany)	Journey planning (multi-modal), Ticket sales, Real time information, Quiet/Busy information, Disruption info,
TrenItalia (Italy)	Journey Planning (rail), Ticket Sales, Real time information
(DBahn (Germany), 2022; Irish Rail (Ireland), 2022; Renfe (Spain), 2022; SNCF (France), 2022; TfL London Underground (UK), 2022; TrenItalia (Italy), 2022)	

These are essential activities for the core parts of the customer journey. However, when we reflect on the actions that take place before one leaves home to entering one's final destination, it is clear that there are many other stages in the complete door-to-door journey.

In the late 1990's the design consultancy IDEO worked with train operating company Amtrak (USA), to help them provide a better passenger experience for new high-speed train service, 'Acela'. Initially this contract was for a new design for the armchairs in the trains. IDEO's lead designers, Bill Moggridge and David Kelley, set about a collaborative process with Amtrak, engaging with ground-breaking immersive methodologies. IDEO observed that the train seating was just one of many components in the overall customer experience. They believed that if the new Acela service were to be successful, then a complete door to door journey would need to be considered (Myerson, Jeremy, 2004, p. 94). For this project, IDEO employed several design strategies and assembled a wide diversity of people, including existing and potential passengers, Amtrak employees, along with their own experts (Brown, 2009). The two teams concluded that from the customers' perspective, a train journey started well in advance of the actual train trip and extended for some time after they had alighted from the train. Both then realised that to successfully provide users with the type of service they were seeking, a

considerably broader perspective of the customers' journey would need to be considered as a whole (International Service Design Institute, 2022). To help understand the different stages within this expansive Amtrak users journey, IDEO proposed a customer journey map of ten stages, shown in figure 1.

Figure 2: IDEO Customer Journey for Amtrak, a larger version of this appears later in this thesis (Self-generated)

Essentially, to deliver a service that ‘met or exceeded the users' needs’, the train service would need to be designed for all the steps in the journey, not simply the actual travelling on the train itself. Several years later in 2014, the METPEX were developing and evaluating a standardised tool to measure passenger experience and establish and benchmark services in which they agreed about this observation on the complete journey. Similarly to IDEO, METPEX deconstructed the passenger journey into different elements to develop a systematic approach to the whole journey that would consider all human factors. The METPEX study also proposed that the key to improvement lies in the understanding of the entire journey in order to gain a deep insight into people’s travel behaviour and, ultimately their needs. However, Professor Andree Woodcock, (the lead researcher on the METPEX project) crucially noted:

> ‘Some stakeholders may not be interested in the broader concept of this customer journey and may be disinterested in parts of it which is felt to be out of their direct control’. (Woodcock, 2017, pp. 32)

Professor Woodcock also noted several important points about the data that different stakeholders collect, concluding that it can impair proper analysis for the following reasons;

- not sufficiently accurate
- out of date
- could be missing parts of the entire journey

- lack of participation from non-transport users
- lack of participation from people who cannot use existing transport choices due to insufficient accessibility.

The term 'journey' is defined as 'something suggesting travel or passage from one place to another' (Merriam-Webster.com, 2020). However, Woodcock et al. (2014) describes a more specific 'public transport journey', which they say can include;

- A walking portion at the beginning or end of the journey
- An in-vehicle portion
- An inter-vehicle or inter-modal transfer where a single vehicle is either not possible or not desirable (due to cost, distance or flexibility)

Woodcock et al. stressed the need to take a systematic approach to the whole journey experience in which each element should be optimised for each user and that each part of the journey, including movement between transport modes and to and from transport gateways, contributed in part to the overall experience (2014). They also note that the choice of transport mode is affected by the sum of previous experiences. Each portion of the customer journey may contribute negatively or positively to the journey experience as a whole. Woodcock et al. break down the customer journey into the following steps;

Table 2: Example of a journey deconstruction from 'Deconstructing the Whole Journey Traveller Experience', Woodcock et al, 2014, pp. 3

1	Assessment of the need for the journey	
2	Journey Planning	Including assessment of mode and time of travel, online ticket purchase, finding routes to the destination, collating information.
3	Preparing for the journey	Including gathering journey artifacts.
4	Movement from the origin to the transport gateway	Negotiating the route from the door to the first vehicle. Little attention is paid to this stage of the journey by transport operators but it is of key importance.
5	Interaction with the transport service	Including payment, ingress, travelling and egress from the transport vehicle
6	Travelling on the vehicle	Including vehicle design, service operation, quality of service, accessibility.
7	Negotiating the transport interchange (with iterative loops from 2 to 6)	This may require change of transport mode, finding the location of transport stops and information for the onward journey.

8	Egress from the service to the destination	This stage is also not well prioritised.

A key point that the researchers noted is that transportation companies often do not prioritise many of these steps.

Literature reviews show numerous other customer journey publications in public transport that seem to omit several stages such as National Rail UK (2019), who describe the journey as Booking and Collecting tickets, Moving through the Station, Boarding the Train and The Journey. Clearly this approach is missing the Planning stages and the Onward travel stages etc and seems less complete than the IDEO and METPEX examples.

2.1.2 User needs throughout the journey

Different community members will have differing requirements and distinct characteristics that may make it more or less complicated for them to utilise public transportation than others. For example, persons with physical disabilities may have problems accessing the transport infrastructure or the vehicles or they may have difficulties hearing or reading information. Persons' economic status may also present issues such as affordability for low-income groups or language barriers for tourists and immigrants. People in rural areas may have greater difficulty accessing transport services than urban dwellers.

2.1.2.1 Accessibility Needs

Each of these different user types compounds the complexity of a journey even further as each group may have particular and distinct needs and these groups need understanding and careful analysis to optimise their travel experience. Susilo, Y., Cats, O. (2014) summarised different passenger groups and their most important characteristics, showing a multitude of similar or different priorities or considerations in their journey in table 3 as follows;

Table 3: Summary of the salient characteristics of different traveller groups
(Susilo, Y.O. and Cats, O., 2014, pp. 6-7)

Group	**Special Characteristics**	**Key Factors**
Full-time employed workers	Regularly incur more temporal constraints than monetary expenditure	Punctuality, reliability, cost
Female travellers	Travel shy, reassurance seeker and cautious planner. Complex scheduling of activities in terms of both time and space and is likely to bring additional bags.	Safe, reliable, affordable and comprehensive access
Parents with small children	More women than men, traveling with buggies and bags	Accessible vehicle and station, onboard space and supportive attitudes
Low income travellers	Tend to be captive to the cheapest mode alternative and spend a significant proportion of income on travel	Availability, adequacy, cost and safety
Children and young travellers	Smaller children highly dependent on their parents' decisions and preferences. For many young teens, travel represents a gateway to adulthood, enabling independence, socialization and a recognition of maturity.	Practicalities (such as cost and speed of journey), flexibility and safety
Older persons	Tend to have more limited ability and strength to move. The feeling of being able to travel independently is closely linked with a sense of self-worth. They have increased difficulty in identifying signs, in reading timetables, listening to loudspeakers and responding.	Physical and emotional barriers, affordability, flexibility, reliability and support facilities
Disabled travellers	Have physical or mental impairment which has a substantial and long-term adverse effect on their ability to travel. Lack confidence when traveling, experience a lack of flexibility in their travel choices and difficult to be spontaneous.	Physical accessibility and availability, support facilities (including information availability), cost, certainty and security and supportive attitudes
Tourists and unfamiliar travellers	Suffer lost-in-translation problem. Have high mobility needs, but limited spatial and linguistic knowledge.	A simpler system, more information provision and more helpful and tolerant staff

The METPEX researchers evaluated the findings of Susilo & Cats further through a series of focus groups across EU member states. Passenger groups with accessibility needs were segmented into two distinct groups, communication impaired and mobility restricted. These restricted mobility groups raised problems with the lack of sufficient priority seating on vehicles for them. They noted that even when provided, they were often occupied by other persons who did not offer to give the seat up. They also noted that their space was frequently taken up as storage space for bulky items such as luggage or baby prams. Vehicle interiors were also often noted to be too narrow (Woodcock et al, 2017).

In preparing for a journey, METPEX research stated that for some people, this is a simple matter of just departing from their location. For others, such as the elderly or mobility impaired, this may be much less straightforward, and this would equally apply to people caring for others. Mobility restricted groups also noted the location of stops frequently being poorly accessible. The poor staffing levels often meant that there was nobody available to assist them with physical access to platforms or with ticketing problems. These groups also favoured travelling off-peak times because of insufficient seating and waiting facilities at busy times. Information relating to service disruption being poorly communicated and a general complexity in accessing information also gave this grouping of restricted mobility cause for concern. It caused them to need to plan their trips days in advance, preventing more spontaneous travelling (Woodcock et al, 2017).

Hickman et al. observed that the interchange design between the origin and the first gateway in the journey is crucial to actual and perceived seamless travel (Hickman et al, 2012). The METPEX research added that this stage might add additional stress on potential travellers, and hypothesize that there may be a point at which this stress may make the journey less attractive, depending on how essential the journey is.

Several factors also associated with poor interchange design identified by Hine and Scott included poor waiting environments, toilet facilities, outdated timetable information, low lighting and personal security levels, poor signage and wayfinding, and carrying luggage long distances confusing pricing and ticketing systems (Hine and Scott, 2002, pp. 221). A fundamental difficulty also highlighted the problems encountered getting from one vehicle to the next and being bored while waiting. Hine and Scott found that interchanges represented a source of anxiety, uncertainty, and powerlessness that could be reduced if up-to-date

information was provided at crucial decision points and greater interoperability between service providers (Hine and Scott 2002). In the scenario of more complex pre-trip arrangements, there may be less likelihood of elderly, mobility-impaired or people with young children undertaking some journeys, ultimately causing isolation in cases. Hine and Scott note that the design affects the perceived time waiting, and the ease of the transfer between vehicles may be difficult for some people. They also note that this experience may give rise to some uncertainty in the mind of the traveller, particularly in terms of personal security, travel information, ticketing arrangements, service predictability, waiting for times etc. (Hine and Scott, 2002, pp. 221).

2.1.2.2 Information Needs

Research from Balcome et al. (2004) and Stradling et al. (2000) observed that the quality of travel information could substantially influence the level of satisfaction with public transport, mainly whether this information is static or real-time and provided in advance, wayside or en-route. Further research by the Department of Transportation USA (2003), Hine and Scott (2000), and Lyons and Harman (2002) describe the factors influencing the usability of the information as design, condition and timeliness of the data. They consider the whole journey experience depends on multimodal information to enable full planning and ease of transfer to 'minimise the effort for the user in acquiring information on mode choice options and can expose the user to information on such options' (Kenyon and Lyons, 2003, pp 16). The METPEX researchers also noted that communication impaired groups experienced problems with the warning systems in use by automatic doors in vehicles and announcements about service disruptions or the service and stops before and/or after boarding, fearing that they could take or be on the wrong service. The senior citizens' group raised many issues that they were unhappy with, some of which somewhat unsurprisingly overlapped with the mobility restricted and communication impaired groups. These travellers also had problems using steps and ramps entering and exiting vehicles, and they had difficulties reaching the kerb or platform edge. They also experienced audibility difficulties with the audio warnings on vehicles with automatic doors and problems locating public toilet facilities (Woodcock et al, 2017). Frequent travellers and commuting groups expressed dissatisfaction with issues from vehicle design and available space for legroom and luggage to announcements and the lack of signage in car parks conveying the number of vacant spaces. Having to stand on busy services, inaccurate real-time information and poor

information during service disruptions also gave grounds for complaint. This group also raised issues surrounding cleanliness, refreshments and the availability of operational toilets on vehicles (Woodcock, 2017).

2.1.2.3 Personal Safety Needs

Female travellers and several other groups highlighted security and anti-social behaviour as problems they have encountered (Woodcock and Osmond, 2017). Tourists and young passengers under 24 years of age commented on the absence of security within stations and a prevalence of pickpockets and people begging. The under 24's indicated that they felt less safe late at night when people were intoxicated and gangs active. Female travellers noted poorly lit areas and a sense of danger that they thought required extra vigilance on their behalf, or in some instances, they needed a switch to a taxi or private car, which was seen to be a safer alternative (Woodcock and Osmond, 2017). Safety and comfort are important aspects of transport user experience as noted by Kim, who explores anxiety and phycological stress in the London transport environment (Kim, 2016). Kim notes the definition of anxiety as described by the Diagnostic and Statistical Manual of Mental Disorders as a 'reaction to an anticipated future danger', which he distinguishes from fear which he defines as a 'real or perceived imminent threat'. This anxiety is accompanied by tension, heightened vigilance and 'cautious or avoidant behaviours' (Kim, J., 2016, pp. 4). Kim's research uncovered anxiety experienced by both men and women in a large number of situations on the London Underground. These situations include;

Table 4: Summary of the anxiety situations (Kim, J., 2013, pp. 3)

Anti-Social Behaviour,	Long Waits	Fear of Getting Lost
Overcrowding	Disruptions	Finding Exits
Too much noise	Missing Announcements	Long Walks
Too much noise	Toilets	Platform Gaps
Late Night Travel	Wayfinding	Unfamiliar Journey
Staircases	Missing Stops	Can't get seats
Transfers	Crime	Moving Slowly
Likelihood of Accident Occurring	Can't See Outside	Not knowing where they are while travelling

Tunnels	Travelling Alone	

Kim concluded that anxiety might be a good criterion that suggests a gap exists between the user's experience and the level of service provided and anxiety can be considered a barrier to using public transport (Kim, 2016).

2.1.2.4 User's Needs - Conclusions

Both Kim and Woodcock deducted that several of the groups, particularly additional needs travellers, had their confidence to travel independently damaged by the effects of insecurity, physiological and psychological tension, and all groups had concerns about the timing of the services, space or availability and general insecurity about safety. All groups also valued any practical support whether from staff or from accessible and easily understood information such as timetables, notices, navigation and wayfinding and the reliability of this information. This is especially important during incidents and service disruptions (Woodcock and Osmond, 2017; Kim, 2016). The METPEX researchers noted that despite the publication of numerous guidelines and standards, there existed a lack of knowledge on what is really valued by different groups of travellers who use different transport modes and the requirements of people who do not use public transport at all (Woodcock and Osmond, 2017). Friman et al. (2011) is cited by them, who also proposed;

> '…We are taking a holistic approach to the study of passenger experience and journey satisfaction, not only from the users' perspective but also of the stakeholders, to provide an essential bridge between action and intention to use more sustainable travel modes' (Friman et al., 2011 cited in Woodcock and Osmond, 2017)

The METPEX team concluded that there had been a general shortage of detailed information about the quality of the whole passenger journey by transport companies, many of whom also overlook 'why people do not use public transport'. They note that many companies are primarily focused singularly on the trip onboard their vehicles and the perceived quality for this alone.

2.1.3 Interactive Systems

Computing systems are also known as interactive systems when the continual interaction level with humans is high. Games and design applications were some of the earliest types of human-computer interactions however with the almost ubiquitous adoption of smartphones and software applications, the use of interactive systems is now almost universal. As is human nature, humans fundamentally differ from each other in terms of skills, abilities, senses, preferences etc. and their use and needs of interactive systems varies. While computer programmers write code to enable the systems to operate, other people/skills are needed to design them in a manner that is efficient and effective and include interaction designers and user experience designers.

2.1.4 Conclusion

The first part of the literature review shows how other researchers have broken down the broader door-to-door customer journey into ten stages, from the earliest moment someone learns about public transport to concluding a trip. The literature then looks at how different community members will have differing requirements and distinct characteristics that may make it more or less complicated for them to utilise public transportation than others. It then informs about many of the various needs of users and groups of users, particularly on information, safety, and accessibility and notes a variety of quality indicators that influence customer satisfaction.

2.2 Why design improvements?

After initially researching literature on the current state of the transport industry, this was followed by reporting on the need for improved transportation systems and examples of additional requirements that some travellers have. This chapter takes a closer look at some of the essential reasons why we should design to improve, e.g.

- Good work practices and standards
- It is against the law not to
- It can make a difference when improvements are made
- It can affect some people significantly

International Standard ISO 9241 defines user experience as 'A person's perceptions and responses that result from the use or anticipated use of a product, system or service' and designers can influence how products/services behave and are used. This field of design touches a wide scope of considerations such as psychology, visual design and is in its essence human-centered or user-centred where people are at the centre of all activities in the development of the product or service. Part of user experience design, interaction design focuses on the core interaction between the user and the system. These designers are familiar with the limits of physical and cognitive interaction and may ensure that the interactive/user experience is as easy and enjoyable as possible. These user experience standards help to ensure better products/services are built thereby improving customer satisfaction. Methodologies and work practices such as scrum and agile provide teams with ways to seamlessly collaborate in the design and development user centred solutions in an iterative manner. Other international standards such as ISO 9000 ensure high quality, customer focused software development when used appropriately by leveraging mechanisms to control and drive the design process.

2.2.1 Legal Obligations

Irelands National Disability Authority (NDA) advises on many legal obligations regarding the accessibility of information and service in the public sector under which public transport is included. The NDA publish a code of practice from which the following legislation is noted below (NDA, 2022).

2.2.1.1. Equal Status Acts, 2000 to 2004: This act prohibits discrimination in providing goods and services, accommodation and education. The sector included in this list is **'**transport or travel'. The act covers the nine grounds of gender, marital status, family status, age, disability, sexual orientation, race, religion, and membership of the Traveller community (Equal Status Act, 2000).

2.2.1.2. Disability Act 2005: This act places significant responsibilities on public bodies to make their services accessible to people with disabilities;

• Under section 26, public bodies must ensure that their services are accessible for people with disabilities by providing integrated access to mainstream services where practicable and appropriate.

• Under section 27, public bodies must ensure that the goods or services they purchase are accessible unless it would not be practicable or justifiable on cost grounds or would result in an unreasonable delay.

• Under section 28, following a request, communications by a public body to a person with a hearing or visual impairment must, as far as practicable, be provided in an accessible format. As far as practicable, the information provided electronically must be compatible with adaptive technology. Published data relevant to persons with intellectual disabilities must also be, as far as possible, made available in easy to read formats (Disability Act 2005, cited by NDA, 2022)

To ensure services are accessible, it is essential to be aware of the obstacles encountered by persons with physical, sensory or intellectual impairments. Obstacles to accessibility for people with disabilities encompass a broad range of both tangible and intangible elements, for example;

• Communication, where presented in inaccessible formats
• Lack of awareness of the needs of people with disabilities
• The physical environment, e.g. design, layout, signage, lighting
• Service design, e.g. where systems, procedures and practices can present obstacles (NDA, 2022)

Information and services can be made accessible when provided in a manner consistent with the needs of those individuals for whom they are intended. This can be facilitated by adopting a proactive and consultative approach to information and service design and delivery (NDA, 2022)

2.2.1.3. Directive (EU) 2016/2102 and S.I. No. 358/2020 – This directive is known as EU (Accessibility of Websites and Mobile Applications of Public Sector Bodies) Regulations 2020 and is signed into Irish law. This directive is focused on the accessibility of websites and smartphone applications for all public sector bodies. Compliance on this directive is routinely

monitored by the National Disability Authority, who publish results and circulate to government and EU stakeholders. (Directive (EU) 2016/2102)

- Ensure all their websites and mobile apps comply with AA WCAG 2.1
- Provide and maintain a detailed accessibility statement
- Include a feedback mechanism and information on asking for support or making a complaint

Scope for this regulation includes;

- Websites & Smartphone apps
- Covers ALL content – not just HTML pages
- Internal intranet systems used by employees etc
- Navigation
- Images
- Videos
- Embedded content
- Forms
- Search

Extranets/intranets

- Archived content
- Office file formats, e.g. Word, PDF

(Directive (EU) 2016/2102, cited by NDA, 2022)

2.2.2 Positive Impacts of improving information – Case Studies

There are numerous studies on the provision of real-time transport information (RTI). Swedish researchers Dziekan and Kottonhoff described the possible effects of real-time displays on public transport customers in 2006 and their research is cited by hundreds of transport researchers since. Their paper, preceded ubiquitous use smartphones and centred upon hardware displays on public transport networks. However, their research is still highly relevant at the time of this research, and perhaps even more so as the capabilities of smartphones have

so significantly evolved. Dziekan and Kottonhoff describe the main effects or impacts of real-time information to transport users in their 2006 paper. The main proposed impacts are;

- Reduced 'perceived' wait time.
- Positive psychological factors such as reduced uncertainty, feeling of ease
- Increased willingness to pay.
- Adjusted travel behaviour such as better use of wait time.
- More efficient travelling.
- Mode choice effects.
- Higher customer satisfaction.
- Better Image.

  (Dziekan and Kottonhoff, 2006)

The effect of a 'reduced wait time' or a somewhat more accurate description of a 'reduced perceived wait time' is a straightforward metric in the passengers experience of just how long they believe that they have waited for their service. Dziekan and Kottonhoff reference a further study by Kronborg et al. which concluded that passengers who had real-time information available overestimated their wait times by 9%-13%, which is considerably less than the overestimation for passengers without real-time info as 24%-30% (Kronborg et al., 2002). A further study by Forsyth and Silcock (1985) noted that a Countdown evaluation project in London showed a perceived wait time drop of 26%.

However in addition to reducing the 'perceived wait time', the 'actual wait time' can be reduced by using real time information as noted by Watkins et al 2011, who observed bus users saving time by arriving at their stop to board the bus closer to the real arrival time, thereby waiting at the actual stop for a shorter time. Some of these bus users commented that they liked their ability to get a coffee because they could see a delay or that they would have to run to the stop because the bus was on time and they themselves were late (Watkins et al 2011). Dziekan and Kottonhoff note the availability of such information in real-time does influence travel behaviour. This is primarily due to passengers being very adaptive to environmental conditions and changes to the same. Knowing more precise details about their intended transport service enables passengers to use any expected wait times for other purposes such as shopping just as

Watkins et al observed. Dziekan and Kottonhoff also noted research by Forsyth and Silcock that described a reduction in the 'dis-utility' of the wait time (Forsyth and Silcock, 1985).

Positive psychological effects were noted by Dziekan and Kottonhoff in their research which include an increased feeling of personal security that passengers feel and experience at their transport stops. They cite a study by Science Applications International Corporation that found that over half of the passengers studied felt reduced anxiety at their stops and an increased sense of security (SAIC, 2003). They also noted in this study that passengers felt that even the presence or existence of real-time passenger information created a 'greater understanding of trust in the public transport system' (SAIC, 2003). Knowing the expected departure time or the amount of time to wait for the next departure contributes to reducing uncertainty and increasing the feeling of control. Dziekan and Kottonhoff also reported that these findings are corroborated by other researchers, Arnstrom (1986) from the early days of real-time information, who concluded that people felt less stress during travel at interchanges when real-time information was available. Dziekan and Kottonhoff also described that real-time info afforded increased ease of use which they wrote to be both physical and cognitive (Stradling, 2002), and the availability of this info generally was found to be trustworthy and contributed to a more straightforward journey (Dziekan and Vermeulen, 2004)

Transport Research Centre in Madrid researched how the adoption of RTPI systems can affect the punctuality, quality of service and users' perception of public bus networks in Madrid (Spain) and Bremerhaven (Germany). Their research from both cities shows a higher perceived service quality when bus stops and buses are equipped with information devices. The network in Madrid experienced a punctuality improvement of 3% and a quality of service improvement of 6%, while the network in Bremerhaven increased by 13%. The perception of the public transport image increased by 14%. The researchers concluded a considerable advantage in having high-quality information systems as some of the barriers to using the networks can be lowered by reducing the waiting time at stops, delays and uncertainty and improving intermodal information. This is concurred by Rezapour and Ferraro who conclude that accurate real time information may even compensate for delays which they say are inevitable (Rezapour and Ferraro, 2021).

Crucially however is the accuracy of real time train information as Rezapour and Ferraro note, that 'inaccurate real-time information would have an aggravated negative impact on the quality

of the rail transport system' (Rezapour and Ferraro, 2021) and the travellers 'trust in RTI depended, to a large extent, on the accuracy and timeliness of the information' (Deng and Chan, 2020).

2.2.3 Improving Autonomy

Design researchers 'Latitude Research' looked at improving autonomy in public transport through a series of studies by asking car users to give up their cars for a week as part of a deprivation study and rely on other forms of transport. Latitude explored whether new technologies and information could improve public transport and generally encourage people to make more sustainable transport choices. Their research showed that the provision of good information could equalise transport mode choices. Latitude researchers reflected that;

> 'real-time and personalised travel information can make public transport a more flexible, equitable and enjoyable experience, thus minimising the perceived experience gap between car ownership and other modes of transport usually considered less convenient or accessible by would-be users'
> (Latitude Research, Deprivation Study, 2011, pp. 2)

In the study, Latitude found that more than two-thirds of their participants cited convenience, control and flexibility as the chief benefits of car ownership, scoring higher than comfort and status. After the week free of driving, four-fifths of the participants felt that car ownership was not essential, particularly if they could access a vehicle through car-sharing or ride-sharing services and leading to a conclusion that; 'autonomy mattered more than ownership' (Latitude Research, Tech for Transit, 2011, pp. 4)

These researchers found that having readily accessible information on all transportation options generally improved people's perceptions of public transport and facilitated users to rediscover their communities, exposing them to new experiences and giving them a greater sense of belonging to their communities. Given that public transport is better for the environment, participants wanted to have information about carbon emissions and calories burned due to their transport choices.

Latitude concluded that easily accessed information is an excellent democratiser of products and services and that consumers themselves do not need to consider themselves a 'car person'.

They suggested that transportation companies ‘make it easy for people to be good’ and move away from an ‘all or nothing approach’ (Latitude Research, Tech for Transit, 2011, pp. 7-8)

By enabling people to make spontaneous decisions to use public services, they could be encouraged to make incremental changes towards public transport. Noting that people do not want any barriers to interoperating with different travel modes and this requires greater collaboration between transport authorities, competitors, and the local community.

2.2.4 Conclusion

The second part of the literature review examines why improvements should be made. Summaries of the 'Equal Status Act', 'Disability Act' and EU Accessibility Directives are outlined, showing the need for full accessibility in both interactive systems and transportation systems in Ireland. A case study shows how improving information can not only improve the experience but empower the traveller to adjust their plans to avoid busy services etc. The review then notes research showing that having readily accessible information improves people's perception of public transport

2.3 How to design?

So far, this study has looked at how improvements can positively benefit the customer experience. Following on from looking at the public transport industry in general, and some reasons why improvements to the customer journey should be subject to further design. The next part of the study looks at how these improvements can be designed with help from the users themselves and what frameworks could help the study be successful. The following section looks at the process of co-designing, drawing on the recently published Irish 'Design for All' standard and takes a general look at user stakeholders roles and their relationship in the industry.

2.3.1 Co-Designing

From the literature, we can deduce that, (1) users have a wide range of needs. (2) the wide range of abilities of users may not be fully understood by service providers. As this study aims to inform future service design for Irish Rail, it is important to choose a good user-centred design framework that will support both the company and their diverse users and needs. Thus the approach undertaken in the study needs to be genuinely user-centred, collaborative and suitable for interdisciplinary teams. The approach would need to probe deeper than traditional focus group style interviews to reveal greater insights representative of each and every participant. The process and methods employed by co-design allow this to happen.

Steen et al. notes that:

> Co-Designing is advantageous when working with teams as it has been proven to lead to more long-term success, more support and enthusiasm for change, and can generate solutions that improve day to day experiences.
> (Steen et al, 2011 cited in White et al, 2021, pg. 248)

This 'enthusiasm for change' and 'generating of solutions' fitted the study, and the mindset of 'leading to long-term success' fitted the aspiration that this study would influence further research. Steen et al. (2011) collated a matrix on the benefits of co-design in projects for organisations, as seen in table 5 from numerous researchers.

Table 5: Benefits of co-design, collated by Steen et al (2011)

	Benefits for the project	Benefits for the users	Benefits for the organization
Improving Idea Generation	Better ideas, better knowledge about customers' needs		Improved creativity and focus on customers. Improved interdisciplinary cooperation
Improving the service	Improved service definition, higher quality and more successful innovations	Better fit of service and needs, contributing to a better experience and higher quality	
Improving Project Management	Better project management, decision making, lower development cost, reduced development time and continuous improvement		
Improving longer term effects		Higher satisfaction, loyalty and more educated users	More successful innovation and more support for change. Improved relationships and public relations

Co-designing also assists when faced with limitations in reaching participants e.g. during the pandemic, the White et al. (2021), who adapted design research to facilitate remote working across interdisciplinary teams to a successful conclusion. These researchers noted a need for 'a platform whereby the voice and ideas of the researchers could be expressed further' and proposed a process of 'co-designing' as it allowed 'a wide range of people to make a creative contribution to the formulation of solutions'. The insights of both White et al. (2021) and Steen et al. (2011) make a compelling case for why co-design will fit both this study and subsequent research.

In terms of defining what co-design is, McKercher (2020) described it as 'designing with, not for, people' (McKercher, KA, 2020, p. 14). With an emphasis on the 'with', this co-designing framework involves groups of people with lived experience in the design process. The Design Council of the UK defines 'the process of designing with people that will use or deliver a product or service' (Burns, C. & Design Council UK, (2020). Froukje Sleeswijk Visser has described these

people mentioned above as the 'experts of their experiences' (Sleeswijk Visser et al., 2005), and the participation of this group of experts and their relationship within design teams are influencing changes in the design process (Sanders & Stappers 2012, p. 23). Co-design is becoming more and more popular in design research as Sanders and Stappers note a changing landscape, referring to transportation service design:;

> Over time, design research activities slowly moved to the front end of the design development process, where designers and design researchers were getting involved with challenges at larger and more significant levels of scale. The challenges ranged from automating ticket sales to enhancing passengers' experiences waiting at airports to the orchestration of collaboration in healthcare services to attacking societal issues like obesity. The means—initially the object of design—became the second step in the designers' work. (Sanders & Stappers 2012, p. 28)

The co-design process is considerably more nuanced person centred and design lead than research activities such as focus groups. Many considerations are employed to generate the best conditions for success. McKercher notes some essential principles. First of all, it is essential to recognise power differentials, e.g. sometimes people with the most power often have the most influence. Sometimes this can be 'regardless of the quality of their knowledge or ideas', which can be problematic either in the sense of conflict or overall success in the project. Where power differentials prevail, it may happen that some people cannot trust that their observations or feedback will be heard on included. They also may not be able or willing to challenge the more powerful when they misunderstand or are incorrect. Organisers and facilitators in co-design need to ensure that groups typically marginalised are included, and they must provide that all participants are comfortable making themselves heard. Trust and the relationships built during this process are critical for the best outcomes. It is also essential to enable people to express themselves through different participatory activities.

As co-design involves gaining a deep understanding of needs, Sanders and Stappers note some techniques for helping to 'bring out the expertise of participants'. These techniques they have found 'essential in getting at the underlying user values that can inspire the design of future ways' (Sanders & Stappers 2014, p. 29). Kelly Ann McKercher notes that we sometimes speak about people instead of with them or think we know what is best for them and do not even ask. It cannot be expected that non-designers or everyday people can turn on creativity instantly, and they need time to get in tune with the process. One activity to help this get started is the

concept of ‘priming’, which involves introducing something they are familiar with or have used previously to jog their memories.

Sanders and Stappers explain the levels of knowledge in people, such as participants in co-designing workshops as per fig 3. The figure shows the depth of knowledge, from surface to deep, and describe methods used to see the highest layer of ‘Explicit’ knowledge, before digging deeper into Observable, Tacit and Latent knowledge.

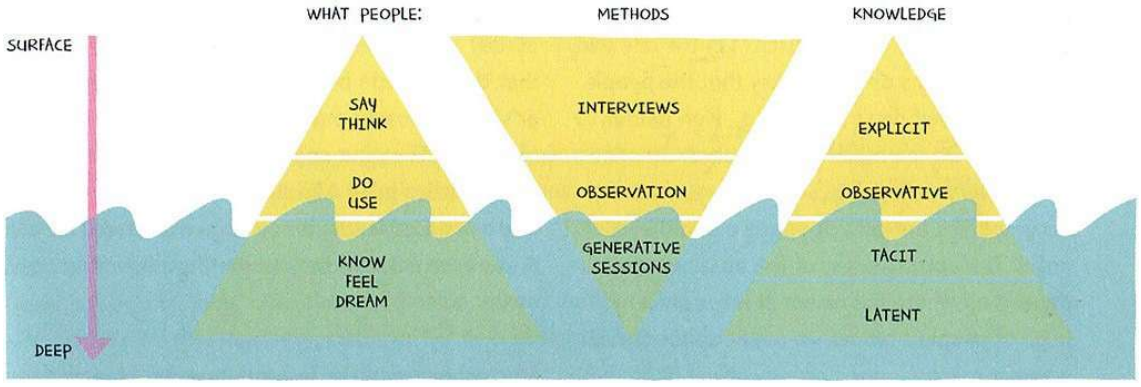


Figure 3: Levels of Knowledge, from Sanders and Stappers © (2020)

By reflecting on and generating stories in explicit and observable knowledge, co-design groups can access more profound knowledge in evaluation and reflection on these stories. Instead of asking people for personal insights in isolation, they make them in the context of a whole layer.

Similarly, participatory design is another framework that also includes all the stakeholders including end users, together in the design process. This is done particularly in the early stages of design to ‘embrace the creativity of everyone’ allowing all to contribute ideas and share an understanding of the problems or opportunities faced (Rosenzweig, R. 2015)

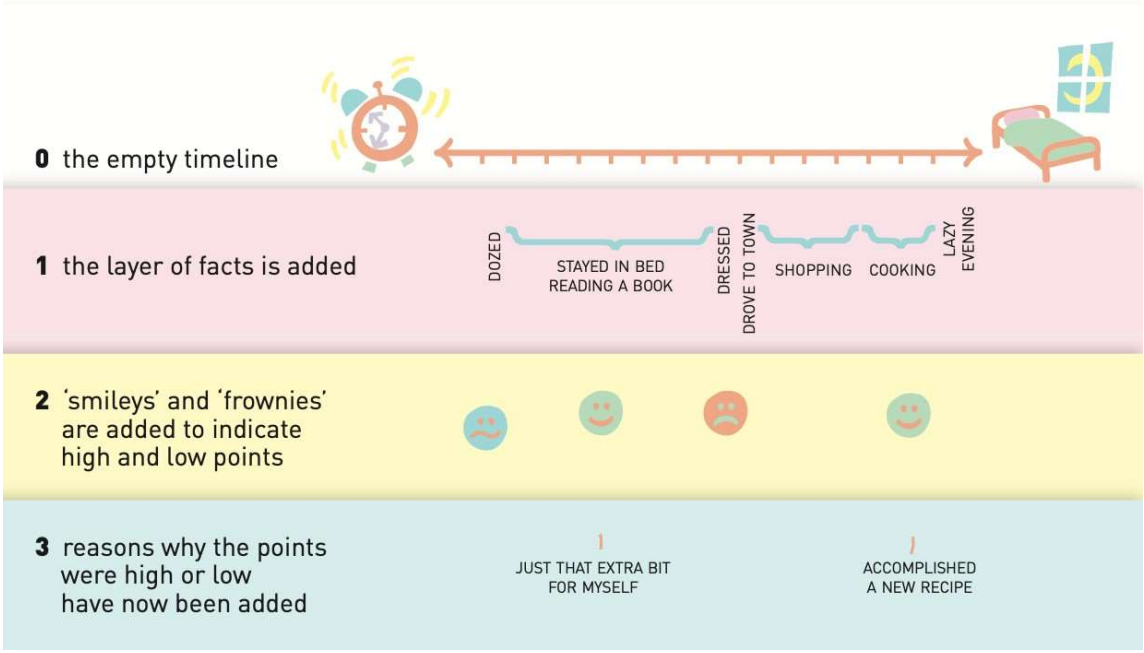


Figure 4: Layering Timeline Exercise from Sanders and Stappers © (2020)

One of the strengths of this layering approach shown above in fig 4 is that people get involved in the story primarily when evaluating it and uncovering the reasons for their evaluations. Doing so may give more accurate results as people will be less inclined to provide evaluations without much thought and then find a narrative to support their assessment.

2.3.2 Framework for Innovation – Double Diamond

The British Design council provide a visual map of the design and innovation process to help both designers and non-designers understand it known as the double diamond as can be seen in fig 5 below. The diamond on the left shows the process of exploring the problem or opportunity more widely and or deeply in a process known as divergent thinking. Then taking more precise actions which is convergent thinking.

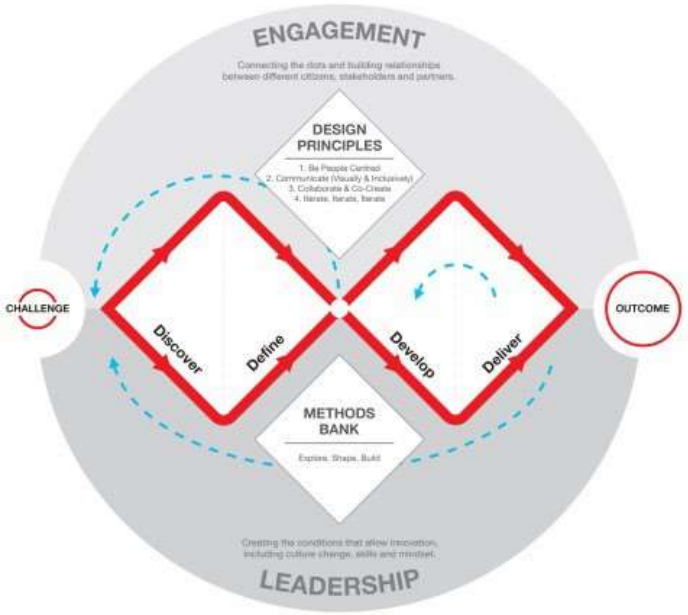


Figure 5: Double Diamond framework for design and innovation, Design Council © (2019)

In the discovery phase people try to understand the problem or opportunity and speak with people who are directly affected. With this insight collated it is possible to define the problem or opportunity in a more comprehensive way. In the develop phase people may address the issue directly with the benefit of the information gleaned from the previous phases and ultimately deliver solutions that will work to solve the issue or challenge.

2.3.3 Irish Standard - Design for All

I.S. EN 17161:2019 is a European Standard and an Irish National Standard entitled 'Design for All – Accessibility following a Design for All approach in products, goods and services – Extending the range of users'. This standard is centred on accounting for human diversity and extending the range of users so that companies and organisations 'value an inclusive and not-stigmatising mindset' that 'supports a culture which prioritises people' (I.S. EN 17161, 2019).

The Design for All standard provides a framework to facilitate the implementation of the best practices for organisations to provide the most accessible products and services as improvements in accessibility will benefit both the users and the organisations themselves. The standard defines accessibility as the 'extent to which products, systems, services, environments and facilities can be used by people from a population with the widest range of user needs, characteristics and capabilities to achieve identified goals in identified contexts of use.' By improving accessibility and broadening the range of potential users, organisations benefit by increasing their market. Populations with greater freedom and independence also benefit society, particularly in sectors with special needs.

The essential tenet of the 'Design for All' standard is that every individual user has their own set of 'needs, characteristics, capabilities, and preferences, which those involved with the provision of services and development of products and goods must be recognised. It is explicitly noted that these needs change significantly during people's lives from early childhood to their senior years and due to life-changing events such as accidents, medical conditions etc. Thus, the needs of a comprehensive set of users have to be considered, and the continual changes to these needs throughout people's lives, to the greatest extent possible (Design for All, 2019).

The 'Design for All' approach requires considering users' needs, characteristics and capabilities, assessment and feedback on existing products or services. The standard recommends that organisations determine how to make their product or service accessible at the earliest opportunity, determining all the internal and external factors relevant to the product or service and its usage. The organisations should also consider their reputation, legal and regulatory options, publications activities, compatibility with assistive technologies and other technological factors. In addition, organisations should consider the capability to deliver and their part in the end to end chain, which is defined as the sequence of information processes

and activities that enable a user to discover, acquire, use, maintain and dispose of a product or service, including post to support and warranty.

The standard notes, in particular, the pertinent example of a train journey as a user obtains information about the train times and facilities, purchases a ticket, accesses departure and destination stations and facilities, boards, uses and leaves the train and may require support or complaint services post-trip (Design for All, 2019).

Several potential drivers for adopting the Design for All approach are identified, including competitive advantage, compliance with public policies, innovation sustainability and human rights. Implementing the 'design for all approach' to improve accessibility and usability may stimulate innovation and creativity and identify new products and services. The potential for meeting users exceeding user expectations, and enhancing the organisation's image, thereby improving customer loyalty, are also critical drivers noted by the standard. For the organisations themselves, they may increase employee motivation and grow in knowledge and an improved sense of organisational pride and social responsibility.

2.3.4 Analysing the stakeholders

In addition to the consideration of users in design research, all stakeholders and their influence need to be considered, particularly in the context of public transportation, where complex interrelationships are often the norm. Most national transport companies have similar stakeholders, and this part of the literature review would apply to most of them, including Irish Rail. It is fundamental to have a thorough understanding of each one and their viewpoints, goals and constraints to analyse and propose improvements to the transport service. This section of the literature review summarises the stakeholders described by Woodcock & Hrin within this sector as shown below in table 6.

Table 6: Summary of stakeholders noted by Woodcock and Hrin (2017)

Government	State institutions engage in a wide range of activities relating to the transport sector, and they are guided by public representatives who have received a mandate from the population via democratic political processes.

Regulatory Bodies	These bodies may be involved in managing contracts and service levels, and often ensuring fair competition within the sector.
Research Institutes	These organisations study a wide range of factors such as the supply and demand for services, modelling to forecast this demand.
Infrastructure Management	All transportation systems that have dedicated infrastructure will have administration bodies responsible for the management of maintenance and development
Operating Company	The most obvious stakeholder in the transport sector is the transport operating company responsible for managing the services, selling tickets and providing information to their customers.
Local Government	Local authorities and local government are broadly responsible for vital public and private services for both people and businesses in defined areas.
Police	Public order and the person safety and security of citizens fall under the remit of the police. In the context of public transport some countries have divisions of their national police service dedicated to public transportation.
Trade Unions	Groups of employees may gather together to form an association or union in order to protect, maintain or improve their working conditions, standards and salaries. When disputes arise they may coordinate protests and industrial action.
User Groups	In some instances, groups of transport users join together to pursue specific objectives, such as campaign for increased accessibility for mobility-impaired users or to increase or protect services to a particular area etc.

Such is the range of the numerous stakeholders; it is clear that any designing for the total journey requires careful consideration, of the network of stakeholders. Ultimately the role and responsibility of each stakeholder may influence this study because some outcomes may not be within the remit of the train operating company, in this case, Irish Rail.

2.3.5 Design Systems / Guides

Many organisations produce a set of documents known as design systems or design guides to make it easier for new projects to be designed and developed. The Nielsen Norman Group defines ‘a design system as a complete set of standards intended to manage design at scale using reusable components and patterns’ (Nielsen Norman Group, 2021, pp. 1). Nielsen Norman notes advantages to having a design system, such as unifying languages across cross-functional teams, creating consistency and speeding up the replication of design in new projects

(Nielsen Norman Group, 2021). As will be detailed in the next section, one of the aims of this study is to produce a framework for future design in Irish Rail.

Vasseloov and Davis (2019) say that the origins of design systems may originate in the eras of the Bauhaus and Swiss design movements but in recent times many of these guides seem to be tailored toward user interface design specifications, design assets and software code libraries. However they say that in some instances, these documents cover other standards such as accessibility and usability (Vasseloov and Davis, 2019, pp. 82). Examples of such design guides include Network Rail's publication 'The Value of Design to UK Rail Infrastructure (2022) and Transport Scotland's 'Design Standards for Accessible Railway Stations', provide an invaluable template for designing at all levels for the public transport sector. These guides could be a useful template or best practice for designing and developing new or improved IT systems particularly in the early stages. There is a gap in providing this type of literature in Irish Rail and one of the final outputs of this study will provide an introductory design book for the company. This will be based on the lessons learned throughout this research in a simplified manner that can be disseminated quickly to help multidisciplinary teams.

2.4 Conclusions

This literature review initially looks at some examples of the state of the industry today in terms of customer experience. Researchers and industry leaders have proposed different versions of the door-to-door customer and show that users' needs are diverse. The study then examines why transit systems could and should be improved and how co-design could help determine the user's needs. As this review progressed, formal peer debrief stages took place with the supervisory team to ensure the appropriate rigour was undertaken.

The following points can be concluded from the literature;

- Door-to-door journey must be considered when looking for improvements
- Different users have specific needs across this journey
- Problems can arise when these needs are unmet
- Improvements; can have a significant impact on users
- Improvements; doing nothing could be against the law

- Co-designing with users will uncover some improvements that are needed
- Suggested improvements can be cross-referenced against Irish Rail's remit
- Irish Rail can implement co-designing in further research
- Design system in the form of a guide or policy for Irish Rail should be introduced (as presently does not exist)

Following this review it is clear that and open user-centered 'ground up approach would be useful to answer the research questions. Many service and product design research studies use grounded theory in this respect such as White, P.J. (2012).

Chapter 3: Research Methodology

The research approach and the methodology are outlined in this chapter. 'Researching through design' as proposed by Frayling (1993) fits best with this type of user-centred design for several reasons and the rationale is described. This chapter also covers the ethical considerations, the reliability of the research and the sample and inclusion criteria used throughout. Also contained in this chapter is a detailed overview of the researcher's positionality. The chapter concludes with a review of the limitations of the study.

3.1 Research Questions

The overall objectives of this research are to inform Irish Rail on new areas for interactive systems for travellers through a user centred design process, learning how to do so and to provide information on how to do this type of design activity in the future. The research questions for this study are as follows;

1. What interactive systems should be designed to improve experience and autonomy for Irish Rail's customer's door to door journey?
2. How can user centred design frameworks assist Irish Rail to meet this?

From the literature review it would seem that if gaps do exist in customer needs and these are addressed that is should be beneficial to the traveller. It would also seem that user-centred designing would also help this objective.

The approach to answering these hypotheses and both research questions is shown in fig 6. Question 1 uses a literature review to provide knowledge on this topic and this knowledge then informs the design of an online survey. The results from this survey then inform a second stage of research in the form of four co-design workshops. The results from both survey and co-design workshops will then answer question 1. For research question 2, the literature review and the co-designing will be used along with all the lessons learned throughout the study and generate a design book for Irish Rail.

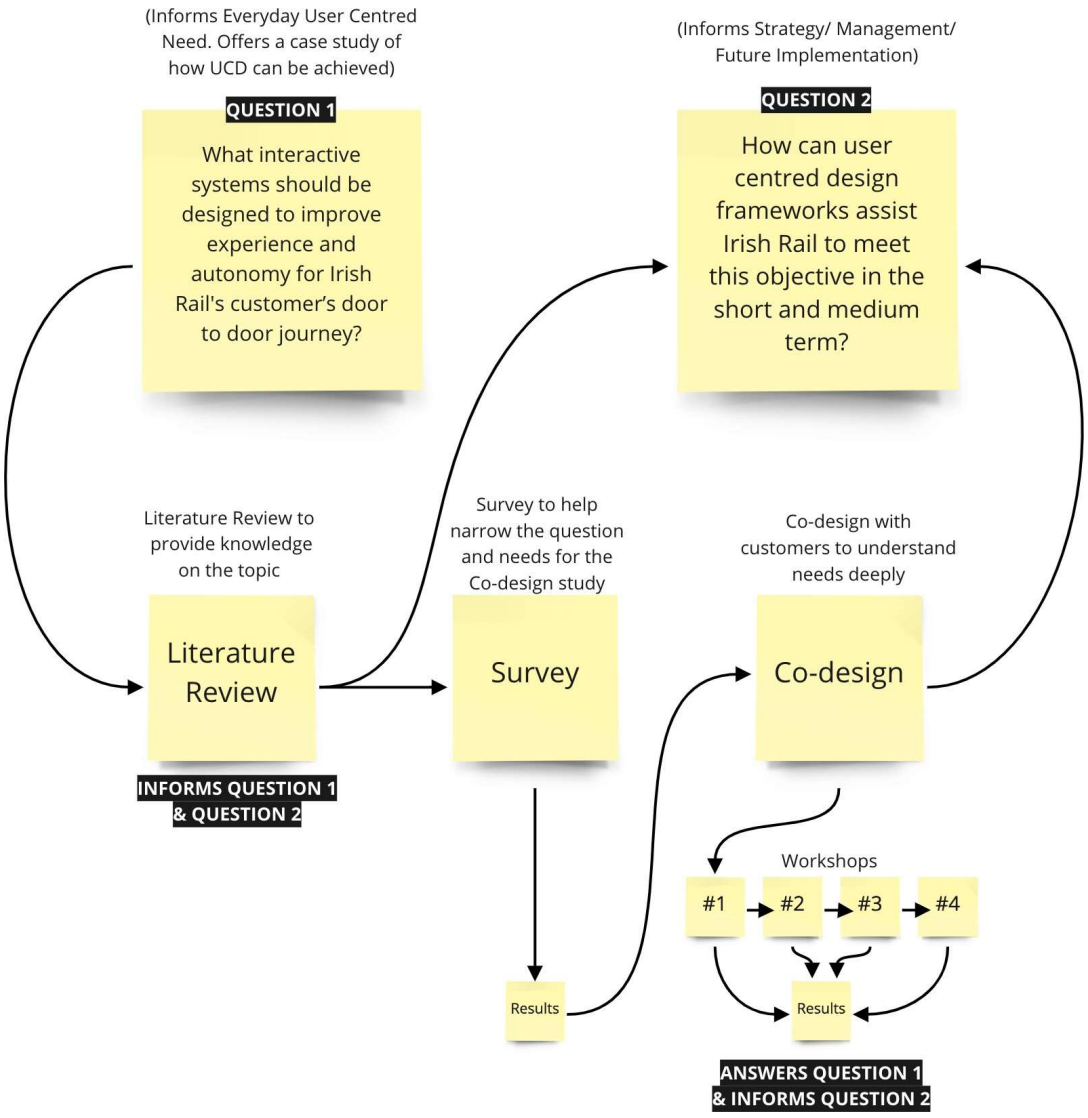


Figure 6: Approach to answering both research questions (self-generated)

3.2 Design Research Approach

The central tenet of this research is the relationship between the researcher and the participants. In contrast to other approaches whereby the researchers are often considered the experts and the participants to be subjected, this research is in partnership with the participants. Accordingly, the research approach in this study is *Research through Design;* somewhat conversely to other methods, the researcher sees the participants as the true experts due to their invaluable lived experience. Christopher Frayling noted three different

forms of design research, 'research into design', 'research about design' and 'research through design' (Frayling, 1993, pp. 20). Research through design describes the process of using design as a research method. With 'research into design' being research into the act of design itself and 'research for design' focused on the production of artefacts through a process of designing, the most apt approach for this user-centred study is research through design.

> '…design is both a making discipline and an integrated frame of reflection and inquiry. This means that design inquiry seeks explanations and immediate results'
>
> (Frayling, 1993, pp. 20)

In 'Design as Practice', Schneider states that research through design can combine practice-based research with reflection and analysis that is 'not restricted to the product on which research is being conducted' (Schneider, 2007, pp. 210).

The benefits of this close relationship between researcher and participants are further noted by Bruce Hanington, who describes it as follows, '…immersion in the research process and direct engagement with users forge a sense of empathy between designer and user' (Hanington, 2010, pp. 11). This close relationship is further described by Sanders and Stappers using Co-Design as 'the creativity of designers and people not trained in design working together in the design development process'(Sanders and Stappers, 2020, pp. 25). But it is perhaps McKercher's succinct description that accurately sums up the choice of design approach for this study; 'Co-Design is Designing with, not for, people (McKercher, 2020, pp. 14).

3.3 Methodology

3.3.1 Epistemological Approach

This research followed a pragmatist paradigm. Pragmatism, unlike positivism and interpretivism which are generally mutually exclusive, is a paradigm whereby pragmatists may have several ways of interpreting the world. Pragmatists carry out research activities to investigate and believe that multiple approaches can provide a broader and deeper understanding of the subject under investigation. As an alternative to a singular method, researchers emphasise the research problem and question and use all approaches available to understand the problem

(Rossman & Wilson, 1985). Creswell & Creswell state that pragmatism is not committed to any one approach and may draw assumptions from both qualitative and quantitative assumptions when engaging in research (Creswell & Creswell, 2018). They say that 'Individual researchers have freedom of choice and in this way, they are free to choose the methods, techniques and procedures of research that best meet their needs and purposes. Using a pragmatist paradigm in research will often result in research with both quantitative and qualitative activity and data because pragmatists believe that both provide the best understanding of the research problem (Creswell & Creswell, 2018).

3.3.2 Methodological Approach

Both qualitative and quantitative data are important in this study, and the integration of both in the process calls for a mixed-methods approach to the research. As the research aims to uncover gaps in users' needs and the qualitative activities will uncover this aspect. However it is also important that this research understands how some themes may affect users more than others and therefore both types of data are essential to the study. Qualitative data tends to be open-ended bespoke where responses are not pre-written and quantitative data includes pre-determined closed-ended responses that may not work best in every situation. Researchers have noted that all methods have biases and weaknesses, so collecting both 'neutralised the weakness of each form of data (Creswell & Creswell, 2018). They describe the strength of this approach as follows;

> 'A mixed-methods design is practical when the quantitative or qualitative approach, each by itself, is inadequate to understand best a research problem, and the strengths of both quantitative and qual research (and its data) can provide the best understanding'. (Creswell & Creswell, 2018, pp. 78)

The research will follow a specific mixed methods sequence known as Explanatory Sequential Mixed Methods, (Ivankova et al, 2006) which commences with an in-depth quantitative activity as a first phase as can be seen in Figure 7. This phase then informs the second phase of qualitative research. Generally in such a research design, these two phases would contain quantitative first and then qualitative however this research diverges slightly.

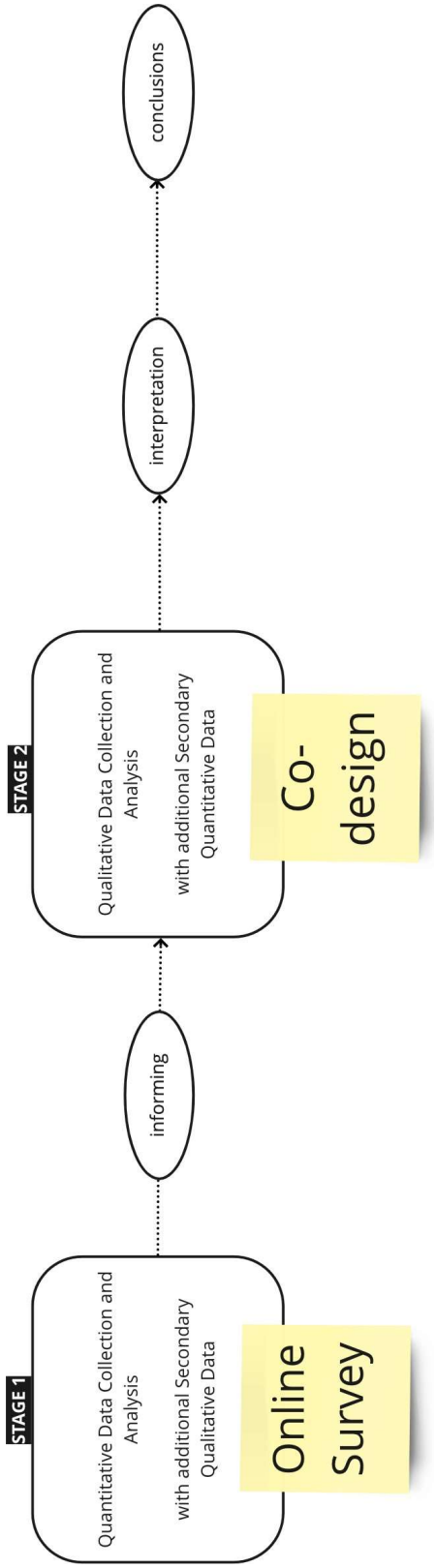


Figure 7: Explanatory Sequential Mixed Methods (self-generated)

Since the second phase is quite often designed after the first phase has been completed and reviewed, the purpose was to fine-tune the next stage of the research based on what has been learned in the previous stage. In this study, secondary qualitative questions were 'nested' or 'supplemented' to obtain the richest possible data and inform the design of the second stage (Morse J, 2015). This was due to the necessity of conducting the qualitative activity in the second step online due to COVID-19 restrictions and the uncertainty concerning the quality of the outcome arising from the online format.

3.3.3 Constructivist Grounded Theory

Grounded theory involves loops of data collection, coding, note-taking and building theories through the emergence of classifications in the data, pursuing the discovery of patterns in the data to conceptualise it. In 2000, sociologist Kathy Charmaz wrote, 'We must look for views and values as well as acts and facts. We need to look for beliefs and ideologies as well as situations and structures' (Charmaz, 2014, pp 524). In doing this, she says that we propose seeking to understand differences and variations among research participants and to co-construct meaning with them, and further says: 'We need to look for beliefs and ideologies as well as situations and structures. By studying tacit meanings, we can clarify, rather than challenge respondents' views about reality' (Charmaz 2014, pp. 525). As a research method, the constructivist grounded theory was considered the most appropriate for this study. The constructivist grounded theory allows for this co-constructing and generation of new theories through participants' own knowledge and the collection of rich and detailed data to gain a deep understanding of traveller's experiences. Glaser and Straus advised however to ignore 'the literature of theory and fact on the area under study, to assure that the emergence of categories will not be contaminated' (Glaser and Straus, 1967, p.45). However other researchers such as Ramalho et al (2015), noted that research with constructivist grounded theory methodologies, 'the researcher's influence - and through him/her that of the reviewed literature—is neither avoidable nor undesirable' and observed that it was part of the 'analytic process' (Ramalho et al, 2015). In the context of this study the researcher uncovers significant literature however remained committed to following the data throughout the research, under the guidance and close scrutiny of the supervisory team. Thematic analysis, which is a method for analysing qualitative data by searching data sets to identify, analyse, and report on repeated patterns found within it (Braun and Clarke 2006) is also used.

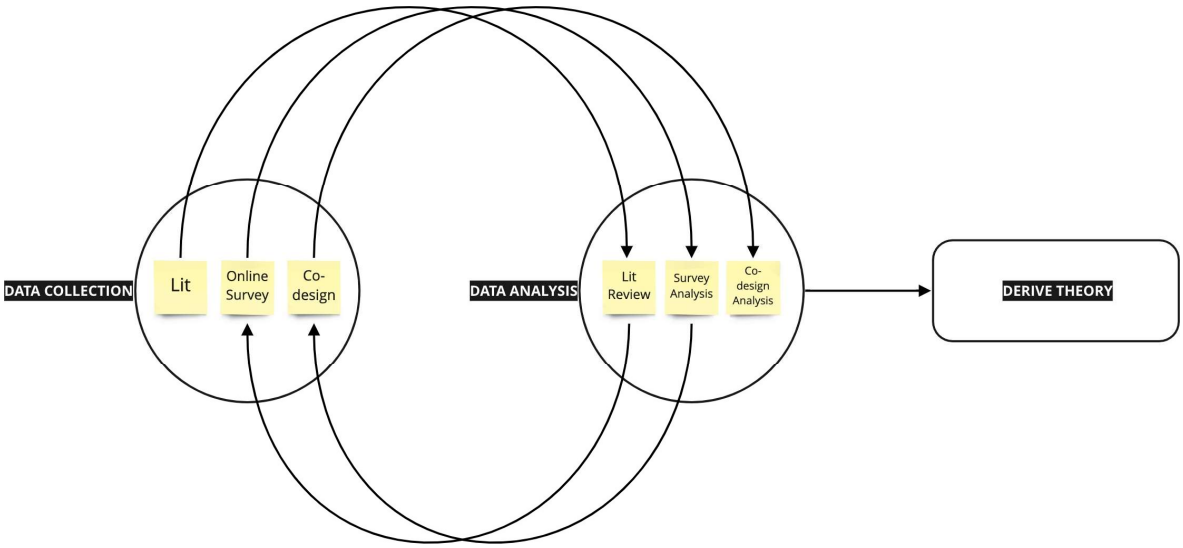


Figure 8: Approach to answering research questions (self-generated)

3.4 Ethical Considerations

The Research Ethics Committee at the Institute of Technology Carlow reviewed the research proposal to conduct this study in advance of the research phase. They subsequently approved after a consultation stage. The Research Ethics Committee gave appropriate scrutiny to the rationale behind the research' inclusion of 'children, individuals with mental health issues, individuals deemed to be of diminished responsibility, and individuals with a physical or intellectual disability. The study involved understanding the needs of current and potential users of Irish Rail's services to propose improvements per the 'I.S. EN 17161:2019 'Design for All - Accessibility following a Design for All' standard; accordingly, participants needed to be somewhat representative of all users. To precluding any sector of society would undermine the user-centred design research.

All participants provided their consent to participate in the research, and no mandatory personal information was collected at any stage. Participants interested in reading the final report were given the option not to use their email address to receive the same. At the commencement of all co-design workshops, the participants were reminded that their presence was entirely optional. Their info would not be recorded during the process. They could discontinue at any time if they wished. The researcher and his supervisor performed notetaking

during the co-design workshops. Full details of the research Ethics application, a notice of approval and consent forms are available in Appendix A.

3.5 Data Management

The research adopted rigorous data management to ensure information security during this study, as any breach would cause reputational damage to the faculty and to Irish Rail. While no mandatory personal information was required to complete an online survey, there would be an e-mail option for participants who wished to receive further communication. A professional tier SurveyMonkey account was chosen for this survey due to the platform's strong data security, anonymity and compliance with the researcher's ethics and privacy obligations. A complex password was used to secure the account, and a single computer accessed this account. During the survey, there were no logins from any other computer. In the survey, anonymous responses were allowed, and IP addresses were not tracked.

After the survey was complete, the data was downloaded to an Irish Rail secured network drive, and the survey account plus its data was deleted. The data on the Irish Rail network is stored in an area accessible solely by the researcher and secured by multi-factor authentication, VPN and the researcher’s own network credentials. E-mail addresses will be held until a final report, in the form of an infographic, is sent to the participants who requested it after the study is assessed. Following this, the e-mail data will be stripped from the survey data and deleted. The researcher, for future research, will hold anonymised responses and results. The researcher used the Microsoft Outlook e-mail account provided by the faculty to communicate with participants. This account is protected by two-factor authentication. Blind copy was used on all email communications and no participants were able to see personal details of other participants. After the study is concluded, the researchers' accounts will be deleted. No personal information was collected in the co-design workshops using Miro's virtual whiteboard software. Participants were identified just by their first name, and no recordings were made except for some routine notetaking.

3.6 Reliability and validity of research

All research in this study was carried out to the highest standards in line with the strict standards from the Institute of Technology Carlow Ethics Committee (Section 3.4 and Appendix D in this report). The research adopted a mixed methodology of qualitative and quantitative research. Several procedures were employed to ensure the reliability and validity of this research. Primarily the design, review and analysis of all activities were subject to rigorous peer debriefing, continuously incorporating feedback and knowledge from experienced researchers. The quantitative parts of this survey were conducted via SurveyMonkey, and some activities within the co-designing workshops were qualitative in nature. In both cases, the scores received are 'meaningful indicators of the constructs being measured' (Creswell & Clarke, 2018). Percentages of travellers with accessibility needs recorded in the survey (Section 5.1.12) are broadly in line with Irish Census data (Disability Federation of Ireland, 2016). Customer satisfaction (Section 5.1.14) is within one percentage point of the same construct as researched by Irelands National Transport Authority (NTA, 2018). The survey and co-design workshops also had qualitative research, and several means of ensuring validity, as recommended by Creswell & Clarke, were employed in the study (Creswell & Clarke, 2018). With 15 co-design participants and 316 survey participants, triangulating responses from several sources was possible. Similar questions in both research activities were cross-referenced against each other, and disconfirming evidence was noted. As the supervisory team joined the workshops, they monitored the reliability and validity during and after them. Appendix E shows an unfiltered snipped of the data received for one sample question in the survey, and Appendix F shows the completed whiteboards after the co-design workshops.

3.7 Sample and inclusion criteria

The initial phase of the study used an online survey (SurveyMonkey) designed by the researcher. Participants were invited via social media channels via the supervisory team, the researcher, the faculty of Design at IT Carlow and Irish Rail. Links to the survey were also sent to some customer groups, including accessibility groups, and posted on internal intranets within Irish Rail. No formal inclusion criteria were applied. No prize or gratuity was offered or given to any participants. The online survey was open for three weeks and captured 316 responses, with 114

respondents providing their email addresses for further information. The majority of respondents indicated they were regular travellers, thus ensuring the sample data would give a good reference data set. Preliminary checks on the sample were made as the survey progressed, by cross-referencing the data collated indicated a diverse range of stakeholder groups, including commuters and long-distance travellers, all genders and travellers with some accessibility needs and without. Some respondents were employees of Irish Rail in roles from customer-facing staff to senior management.

Table 7: Evidence of diversity cross-referenced during the survey and co-design workshops

Question	**Diversity Evidence**
How often do you make trips?	Responses show a mix of 'seldom', 'regularly' and 'frequently'
Do you have any mobility problems?	4% of respondents did answer yes and some did request to participate further
Do you have any communication restrictions?	10% respondents did answer yes and some did request to participate further
E-mail address option for follow up	Respondents to this question included male and female names in the email addresses. Several were also employees of Irish Rail and several of the names and their roles within Irish Rail were known by the researcher. Many respondents used college email addresses, government agency and private emails.
Open questions	Terminology input through open questions included DART, Enterprise and many different station names from the network giving a sense of the broad reach and representation via the survey
During the co-design workshops many of the participants spoke about their own personal experiences which revealed a good mix of diversity and experience.	

Respondents who provided their contact email addresses were invited to participate in the co-design workshops and given several times and dates. A total of four co-design workshops were undertaken, in which fifteen people participated.

3.8 Researcher Positionality

As with all studies that include any qualitative methodologies, it is possible that external factors may influence the researcher. The process of analysis was subject to close supervision and peer review to minimise any unconscious bias of the researcher.

The researcher's own lived experience in the field of the subject of study provided a level of expertise and potential bias, an employee of Irish Rail with over twenty years in the ICT field within the company. However, the company had no influence at any stage during the research and no issues or biases were flagged during the frequent peer reviews undertaken.

As a regular long-distance commuter and a graduate in Design and Innovation at The Open University (UK), the researcher has a unique understanding on the major pain points experienced by travellers. Being severely deaf, the researcher is acutely aware of the challenges travellers with accessibility needs face.

3.9 Limitations of the Research

Some of the research was conducted during the COVID-19 pandemic during a period that many travellers were working from home. Many Irish Rail services themselves were curtailed by the authorities managing the pandemic. The initial survey was undertaken during these restrictions, and it is possible that some travellers did not participate because they were not actively commuting. As social media was used to recruit participants, it is also possible that regular followers were less connected with these digital channels and unaware of the research.

The co-design workshops also took place during the COVID-19 pandemic and restrictions. Instead, they took place online via video conference (Microsoft Teams) and virtual whiteboard (MIRO). Some of the invitees who accepted the invitation to the co-design workshops did not join online, possibly due to technical troubles or last-minute issues.

Participants co-design workshops were purposefully recruited to ensure a diverse sample of participants by looking at their responses in the survey. The final sample of participants included commuters, long-distance leisure travellers, the staff both front line and senior managers, fellow students and the researcher's design peers. Ideally, further stakeholder groups from

governmental agencies, authorities and political representatives would be included however this was not feasible for an academic study during a pandemic.

A large amount of data was collated during the survey and co-design workshops. As much of this data required coding and analysis, there is the potential for some errors or misunderstandings; however, the data capture and analysis has been overseen by the researchers' supervisors during regular peer review meetings.

People with no interest in public transport were not likely to have seen the survey and while they were not expressly barred from participating, the structure of the study was tailored towards at the very least occasional travellers.

Chapter 4: Design Research

Following the literature review, particularly regarding the customer journey and the customers' needs, the research needed to localise the insights for the Irish context. As most of the resources focused on international sources, it was essential to verify for Ireland and Irish Rail.

Due to the pandemic, many field research activities would not be possible, and there was much uncertainty and restrictions implemented by law. For the research to be successful, there was a need to plan for the possibility of not being able to undertake any face to face research activity. Thus, the research planning was crucial as the study would need both broad and deep insight to be successful.

4.1 Design research during the COVID-19 Pandemic

As indicated in the Preface of this report, the global COVID-19 pandemic was widespread during this research period. At the time of the research activities, no in-person research was possible, and the design research was planned and implemented to be fully compliant with all restrictions.

4.2 Designing the survey

The initial survey needed to be carried out online for COVID-19 restrictions and social distancing reasons. Several online survey software service systems, such as Google Docs, Microsoft Forms, etc., were considered to host the survey. However, a professional tier SurveyMonkey account was chosen due to the platform's strong data security, anonymity, and compliance with the researcher's ethics and privacy obligations. By conducting this survey online, there would be no unnecessary personal interaction and would potentially reach users who may be working from home and not actively travelling.

In designing the survey, the key stages of the IDEO customer journey / Amtrak Acela (USA) and many of the key findings in the METPEX research were compiled together in a mind map. These questions were refined and validated in consultation with the supervisory team to ensure the research questions were addressed and insights from the passengers would be relevant.

The survey was designed to ensure both depth and breadth of responses. In order to achieve this, qualitative and quantitative questions were formulated to take both a broad view of the

customer journey and dig deeper to reveal the thoughts and feelings experienced by the travellers as they travelled from door to door. In the first stage of this mixed-methods research, this initial survey would commence with a strong quantitative orientation but with some qualitative questions to yield a richer data set to inform the next phase.

Quantitative questions were asked for almost every stage of the customer journey. As noted by Dolnicar and Grün (2007) some answer formats are preferred by respondents and this may influence the willingness to participate, however no single format is universally preferred. The simplicity and speed of binary answers however seems to be the most preferred. Their study recommends that the preference of answer formations should ideally be tested in advance for the construct being researched. Accordingly, a 3-point scale was used to obtain a rich data set in the shortest possible time.

Questions such as ‘Do you encounter any sensory or communication restrictions when using public transport?’ or ‘When planning a new trip, do you check if there is a train service near your destination?’ generally yield yes or no answers and provide relatively straightforward data and analysis. These questions are usually less time consuming for participants to complete and allow for testing the validity of some perspectives they may have experienced, which have been mentioned throughout the literature review. However, many of these types of questions do not glean more profound insights into the participants' thoughts and feelings, which would be required in follow on research activities.

However, to gain a fuller understanding of the thoughts and feelings of the participants, the survey included numerous qualitative type questions, e.g. ‘Can you briefly describe what is on your mind when setting out on a journey? These questions are open, and the participants could mention anything they wished to. They are not prompted to select from a group of answers and can be as brief or as long as they want to be. While this type of question is commonly more suited to in-person interviews, the researcher mixed these more extended types of questioning into the survey. A disadvantage of these open questions is the length of time that may be taken to answer. However, the researcher balanced the need to obtain good research information with an appropriate completion timeframe. With the survey drafted, the researcher asked for a peer review from the supervisors and made several changes based on this feedback. The updated survey was then sent to a closed group of the colleagues who work with the researcher

to test the survey and check if completable within the 10-minute timeframe; however no further changes were needed.

The study also needed to verify some preconceptions held by the research to this point. Several questions were designed with this in mind based on customer journeys where the rail portion is just a segment of a much wider number of stages forming a door-to-door journey. Some questions were designed in the survey to gauge the level of people who had some form of accessibility needs and also, in general terms, how satisfied or otherwise people were with Irish Rail.

From conducting trial runs of the survey, it was concluded that approximately ten minutes was the maximum time that respondents could be expected to complete it. From a list of several dozen questions, the number of questions was reduced to 37, simplifying the language used and shortening the questions and answer choices. Due to the time involved in completing the survey, the researcher added the option for participants to skip any questions if they felt they were not relevant or too busy to answer fully. Bearing in mind that the participants would give up this estimated 10 minutes of their time. Participants were given an option to add their email address at the end of the survey if they wished to participate in further stages of the study.

With the survey drafted, the supervisory team provided more feedback. The updated survey was then sent to a small group of the researchers' colleagues to test it and check if it was completable within the 10-minute timeframe; however, no further changes were needed. For data security, multi-factor authentication was set up on the account and access was restricted to a single device, the researcher's computer, which is protected by a password, firewall and virtual private network (VPN)

Table 8 shows the survey questions generated, showing how they relate to the different stages of the journey and including some further questions to learn more about the research question and the data quality. As may be seen, the survey is primarily qualitative but with qualitative questions to gain deeper insights into crucial parts of the journey.

Table 8: Survey questions mapped to the stages of the door-to-door journey

	Quantitative Questions	**Qualitative Questions**
Learning	Generally speaking do you think most people in Ireland know about Irish Rail?	

	Do you think information on Irish Rail is easily obtained?	
	Do you think it is easy to compare advantages or disadvantages of train travel with other modes of travel?	
Planning	How do you find out about train timetables and prices? Tick all that apply.	
	When planning a new trip, do you check if there is a train service near your destination?	
Starting	Do you feel that you have all the information that you need before setting out?	Can you briefly describe what is on your mind when setting out on a journey?
Entering	When you arrive at the station, is it easy to access and navigate?	What is on your mind when entering the station.
	Is it easy to park your bike, scooter, car etc?	
Ticketing	How do you usually purchase your ticket?	Why did you choose this method? (Purchasing ticket)
	Do you find purchasing tickets easy?	
Waiting	Is your safety and security a concern as you wait?	What is on your mind when waiting for the train to arrive?
	How do you keep informed about the train as you wait?	Is there anything that would make waiting in the station better for you?
Boarding	Do you feel confident when boarding?	As your train arrives what is on your mind?
		Is there anything that would make boarding easier for you?
Travelling	Is your safety and security a concern while travelling?	What is on your mind as you travel?
	If delays occur, do you feel sufficiently informed?	Is there anything that would make travelling more enjoyable?
		If train A was slightly quicker but very busy and train B was slightly slower but very quiet, generally speaking which would you take?
Arriving		What is on your mind as you near the end of the train trip?
Continuing	Typically, what are your next steps? Tick all that apply.	What is on your mind as you arrive at your final destination?
Research Question	Generally speaking, do you feel sufficiently independent in your mobility options and freedom to travel?	Is there anything that would improve your general mobility and freedom?
	Are you comfortable using smartphone and apps?	
	Which of the following often feature in your door to door trip? Tick all that apply.	
Accessibility	Do you have any physical restrictions with regards to your mobility on public transport?	
	Do you encounter any sensory or communication restrictions when using public transport?	
Customer Satisfaction		Generally speaking, are you satisfied with your whole journey?
Data Quality	How often would you make trips on Irish Rail (in normal times pre covid)?	

No personal information would be mandatory, and no demographic information would be solicited in this survey. The study needed to be open to everyone, and there was no attempt to block children or any vulnerable adults from completing the survey. Through the Ethics Committee at IT Carlow, it was noted that the views of these very people were essential to the study and omitting this group would adversely affect the study. No demographic related questions are included, which was felt would convey the absence of any hierarchy of opinions in the survey. This is because it can be deduced sometimes that one group of participants' opinions may be more important than some others, a subtle hint that every opinion was essential to this research.

4.3 Recruitment of participants

Recruitment of participants to complete the survey was via social media and email. A short link was generated via SurveyMonkey and embedded in text requesting people to participate. Additional details explained that the research was for academic purposes and to be used looking for new technologies to improve the door to door experience and that no personal details were required. Irish Rail Corporate Communications Department were asked to share a link to the survey, asking customers to complete it. Also invited to participate on behalf of the researcher by the Irish Rail Customer Experience Manager were some accessibility organisations in Ireland, including the National Council for the Blind and Central Remedial Clinic, Centre for Excellence in Universal Design, National Disability Authority.

Figure 9 shows the start page of the survey and some of the social media accounts where the invite was circulated.

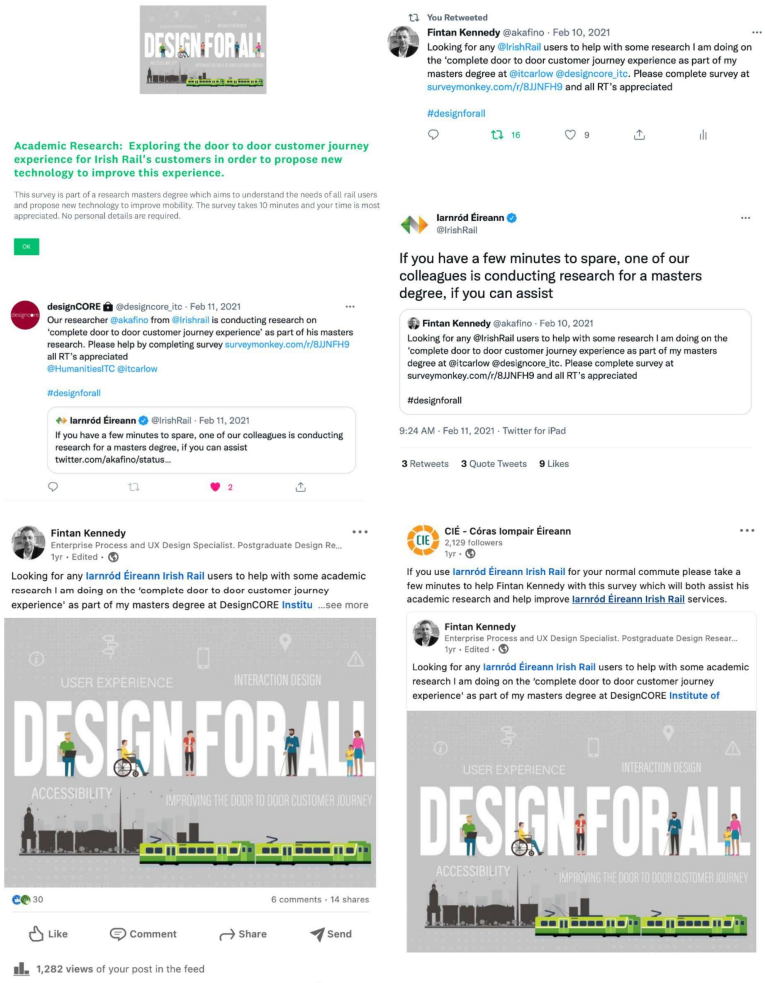


Figure 9: Participant recruitment via social media

When recruiting participants, most of Irelands' workforce was working remotely, and all third-level institutions were operating online only. However, with Irish Rail's extensive social media presence of over 180,000 followers, the survey reached over 18,000 people. With a 100% completion rate, the study received 316 responses and the average time spent was 8 minutes 42 seconds, comfortably within the 10-minute target.

4.4 Survey Analysis

After three weeks and with the number of respondents passing three hundred, the visibility on social media declined and the response rate slowed down. A 'theoretical saturation' point was

reached whereby the responses were not adding anything new to what was already captured (Strauss & Corbin, 1998, pp. 143). A large amount of qualitative data was collected, requiring a significant amount of work to process the survey. Data captured was exported into Microsoft Word, Excel and Adobe PDF file formats. As this data included both quantitative and qualitative. The built-in functionality of SurveyMonkey and Microsoft Excel to calculate the quantitative info.

4.4.1 Manual Coding

The built-in functionality in the survey software SurveyMonkey was used to calculate the results of the quantitative responses providing totals and percentages. For the qualitative responses however, the instrument would be the researcher. With approximately 4,500 individual responses (survey and co-design responses), this was a good opportunity to delve deep into the thoughts and views of travellers by undertaking a manual process. However with such a large amount of data, an organising system would be necessary for a solo part-time researcher to be consistent and 'tease out the layers of meaning' (Bell & Waters, 2018, pp. 38). Accordingly, Tesch's Eight Steps (Tesch, 1990, pp. 86) was used because of the sequence and stages outlined in this process.

As the survey was carried out online, the respondents completed all the text input and dialogue box options; therefore no audio or video recordings needed to be transcribed etc. The online survey was conducted unsupervised, so no additional notes were recorded, which would ordinarily need to be compiled and transcribed. With the survey closed, the research was initially organised, disassembling the data captured. This involved manually compiling parts of it into chunks and generating tags or labels known as 'coding'. This coding process shown in fig 10, 11 & 12 and comprised of finding words and phrases which were clustered in a single question response or seen throughout all the data, and the code names tended to be the participant's own descriptive terms. Coding via the Tesch's Steps method involved reading through all the responses to obtain a broad sense of the data. Some individual responses were then selected, and the general substance of these were reflected on, considering the author's context. Following on from this, all the responses were reviewed with brief note taking (Tesch, 1990, pp. 86). With some notes from the overall survey and some individual responses, lists of

topics emerged, which were graded by the frequency that they were mentioned. This coding process was similar to White (2012).

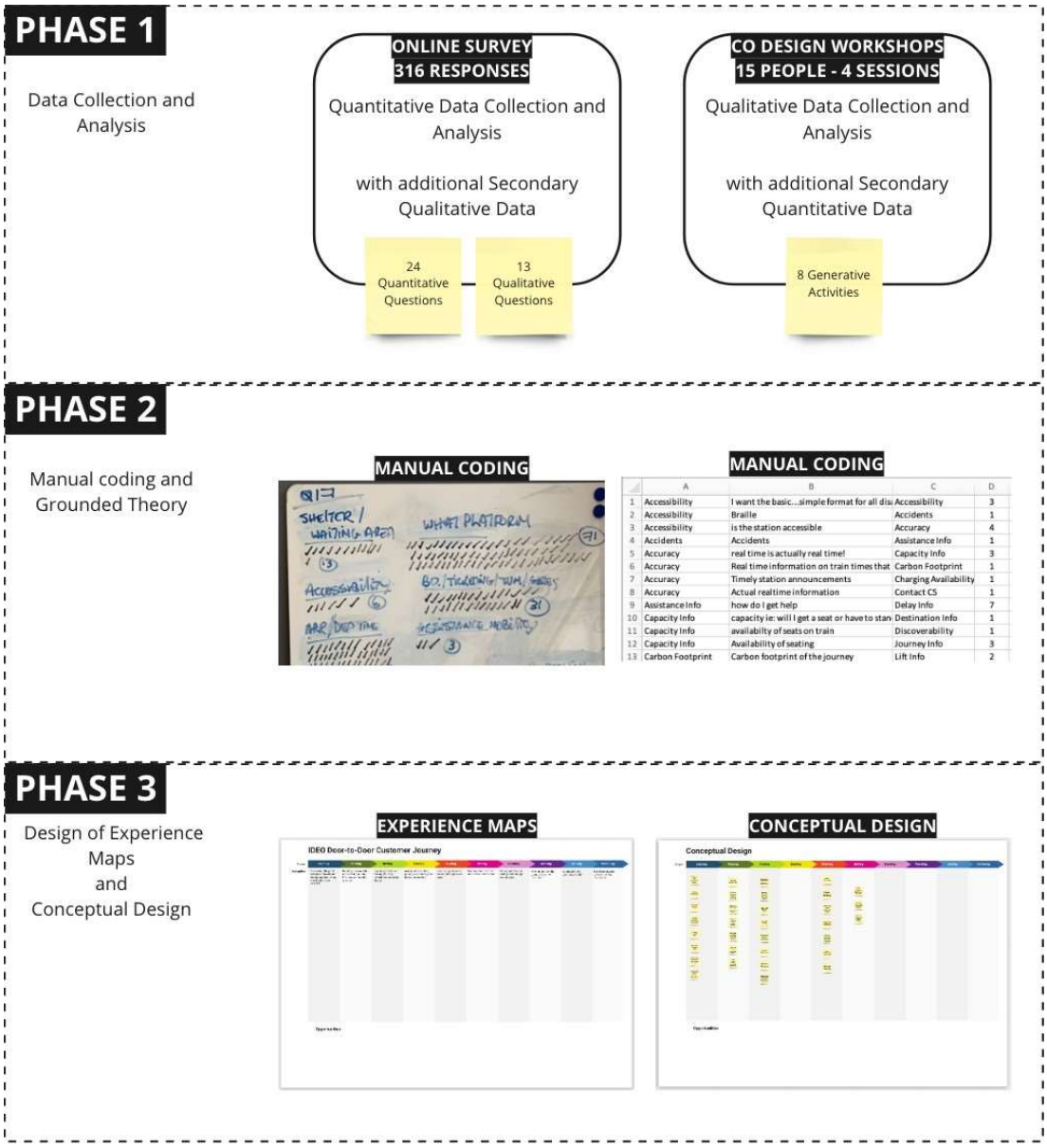


Figure 10: Coding process over three phases

This gave a temporary set of topics to begin analysing all of the survey data. Topic names were simplified and similar ones were clustered together. Many of the codes were expected, terms that would make common sense in the general nature of the study, such as ‘punctuality’, ‘duration’, ‘overcrowding’, etc. However, some emerging codes were somewhat surprising, such as the choice of using ticket vending machines being ‘don’t have to speak to anyone’ and

'like human interaction' for other participants choosing to buy from the ticket office. After the complete set of responses was given a preliminary coding, refining and the wording of these codes to be more descriptive and re-starting a process of refining them further.

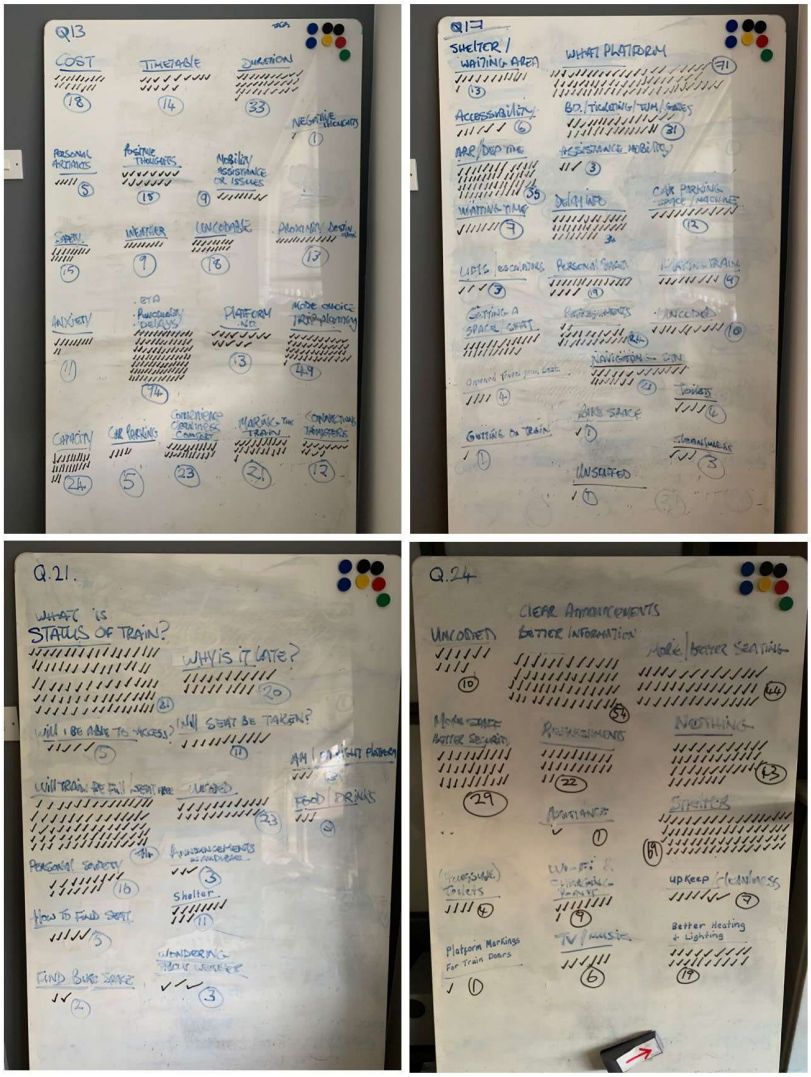
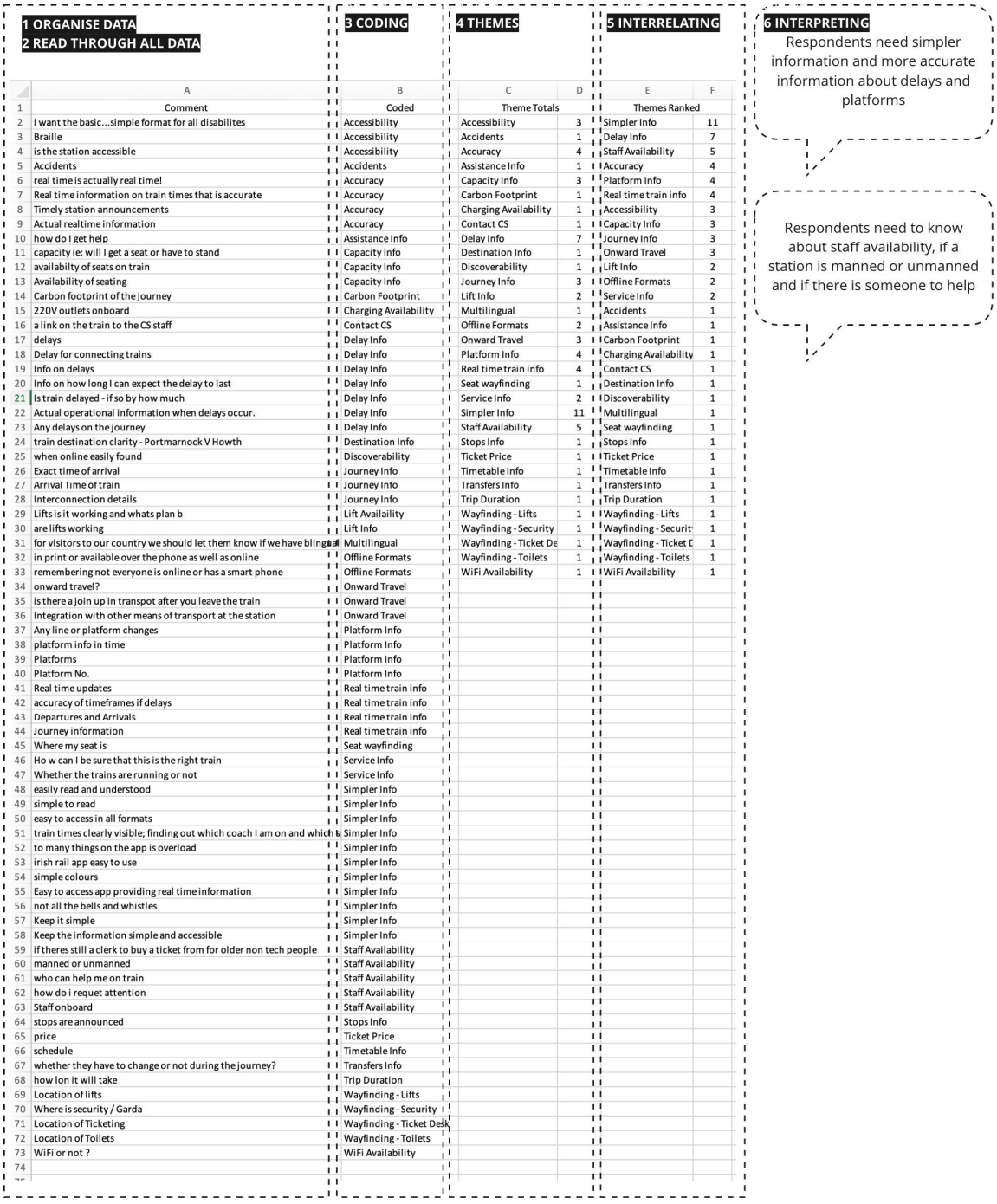


Figure 11: Manual Coding Process

With the volume of responses from the survey (316 responses to 13 open text questions) a whiteboard was used as shown in figure 10. Microsoft Excel was used during the coding of the qualitative responses during the co-design workshops as shown overleaf in figure 11.



	A	B	C	D	E	F
1	Comment	Coded	Theme Totals		Themes Ranked	
2	I want the basic...simple format for all disabilites	Accessibility	Accessibility	3	Simpler Info	11
3	Braille	Accessibility	Accidents	1	Delay Info	7
4	is the station accessible	Accessibility	Accuracy	4	Staff Availability	5
5	Accidents	Accidents	Assistance Info	1	Accuracy	4
6	real time is actually real time!	Accuracy	Capacity Info	3	Platform Info	4
7	Real time information on train times that is accurate	Accuracy	Carbon Footprint	1	Real time train info	4
8	Timely station announcements	Accuracy	Charging Availability	1	Accessibility	3
9	Actual realtime information	Accuracy	Contact CS	1	Capacity Info	3
10	how do I get help	Assistance Info	Delay Info	7	Journey Info	3
11	capacity ie: will I get a seat or have to stand	Capacity Info	Destination Info	1	Onward Travel	3
12	availabilty of seats on train	Capacity Info	Discoverability	1	Lift Info	2
13	Availability of seating	Capacity Info	Journey Info	3	Offline Formats	2
14	Carbon footprint of the journey	Carbon Footprint	Lift Info	2	Service Info	2
15	220V outlets onboard	Charging Availability	Multilingual	1	Accidents	1
16	a link on the train to the CS staff	Contact CS	Offline Formats	2	Assistance Info	1
17	delays	Delay Info	Onward Travel	3	Carbon Footprint	1
18	Delay for connecting trains	Delay Info	Platform Info	4	Charging Availability	1
19	Info on delays	Delay Info	Real time train info	4	Contact CS	1
20	Info on how long I can expect the delay to last	Delay Info	Seat wayfinding	1	Destination Info	1
21	Is train delayed - if so by how much	Delay Info	Service Info	2	Discoverability	1
22	Actual operational information when delays occur.	Delay Info	Simpler Info	11	Multilingual	1
23	Any delays on the journey	Delay Info	Staff Availability	5	Seat wayfinding	1
24	train destination clarity - Portmarnock V Howth	Destination Info	Stops Info	1	Stops Info	1
25	when online easily found	Discoverability	Ticket Price	1	Ticket Price	1
26	Exact time of arrival	Journey Info	Timetable Info	1	Timetable Info	1
27	Arrival Time of train	Journey Info	Transfers Info	1	Transfers Info	1
28	Interconnection details	Journey Info	Trip Duration	1	Trip Duration	1
29	Lifts is it working and whats plan b	Lift Availaility	Wayfinding - Lifts	1	Wayfinding - Lifts	1
30	are lifts working	Lift Info	Wayfinding - Security	1	Wayfinding - Securit	1
31	for visitors to our country we should let them know if we have bling	Multilingual	Wayfinding - Ticket De	1	Wayfinding - Ticket D	1
32	in print or available over the phone as well as online	Offline Formats	Wayfinding - Toilets	1	Wayfinding - Toilets	1
33	remembering not everyone is online or has a smart phone	Offline Formats	WiFi Availability	1	WiFi Availability	1
34	onward travel?	Onward Travel				
35	is there a join up in transpot after you leave the train	Onward Travel				
36	Integration with other means of transport at the station	Onward Travel				
37	Any line or platform changes	Platform Info				
38	platform info in time	Platform Info				
39	Platforms	Platform Info				
40	Platform No.	Platform Info				
41	Real time updates	Real time train info				
42	accuracy of timeframes if delays	Real time train info				
43	Departures and Arrivals	Real time train info				
44	Journey information	Real time train info				
45	Where my seat is	Seat wayfinding				
46	Ho w can I be sure that this is the right train	Service Info				
47	Whether the trains are running or not	Service Info				
48	easily read and understood	Simpler Info				
49	simple to read	Simpler Info				
50	easy to access in all formats	Simpler Info				
51	train times clearly visible; finding out which coach I am on and which s	Simpler Info				
52	to many things on the app is overload	Simpler Info				
53	irish rail app easy to use	Simpler Info				
54	simple colours	Simpler Info				
55	Easy to access app providing real time information	Simpler Info				
56	not all the bells and whistles	Simpler Info				
57	Keep it simple	Simpler Info				
58	Keep the information simple and accessible	Simpler Info				
59	if theres still a clerk to buy a ticket from for older non tech people	Staff Availability				
60	manned or unmanned	Staff Availability				
61	who can help me on train	Staff Availability				
62	how do i requet attention	Staff Availability				
63	Staff onboard	Staff Availability				
64	stops are announced	Stops Info				
65	price	Ticket Price				
66	schedule	Timetable Info				
67	whether they have to change or not during the journey?	Transfers Info				
68	how lon it will take	Trip Duration				
69	Location of lifts	Wayfinding - Lifts				
70	Where is security / Garda	Wayfinding - Security				
71	Location of Ticketing	Wayfinding - Ticket Desk				
72	Location of Toilets	Wayfinding - Toilets				
73	WiFi or not ?	WiFi Availability				
74						

Figure 12: Manual Coding in Excel, sorting, categorising and interpreting

Details on the analysis and results of this survey are available in Appendix X. For the purposes of selecting themes to carrying into co-design workshops 6 main themes emerged as may be seen in figure 13.

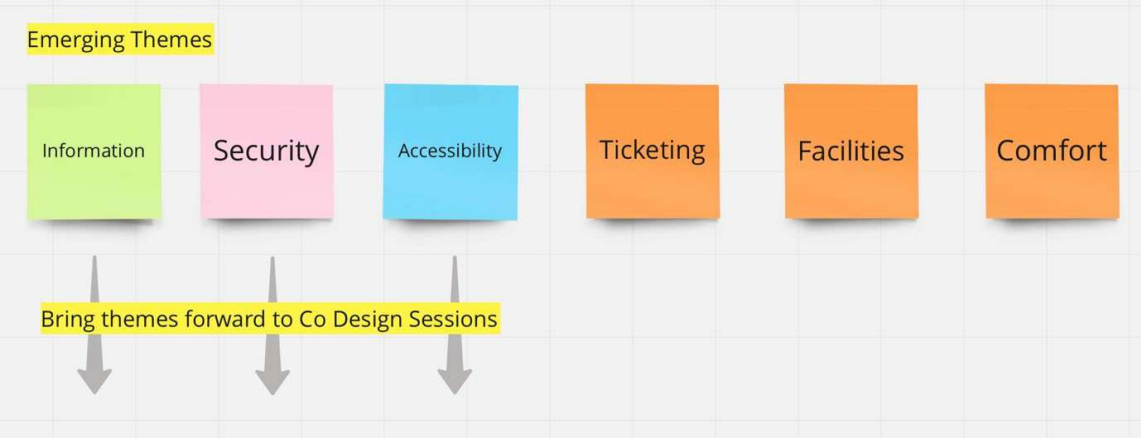


Figure 13: Emerging themes from survey, three of which brought forward for further research

From the literature review it was concluded that there was already sufficient knowledge on the Ticketing theme and the probability that further research on the Facilities and Comfort themes would yield information on improvements out of the general 'technology' improvements posed by the research question. Accordingly, the themes of Information, Security and Accessibility are chosen for further research by co-design in the next stage of the study.

4.5 Designing for Co-Design Workshops

From the initial survey (Section 4.4 – 4.5) and thematic analysis based on the responses, the themes, Information, Security, and Accessibility were taken forward for additional and deeper research and explored further. As noted in the literature review (Chapter 2), user-centred design is called for to find ways to improve the journey. A means to broadly validate the preliminary survey findings and dig deeper into the travellers' needs and underlying thoughts on information, security, and accessibility was required. A co-design strategy as reasoned in the literature review and methodology sections of this thesis was designed

In ordinary times, co-design workshops would be conducted in person. However, the social distancing requirements for COVID-19 meant this research would need an alternative approach. Research from White et al, 2021 describe a successful design research conducted online which would suit this study (White et al, 2021, pp 248). Virtual whiteboard software application Miro™ was chosen as the tool to use with Microsoft Teams for video conferencing.

Following on from peer reviews with supervisors the online co-design sessions were decided to be a maximum of one hour in duration. This length of time was due to a number of reasons;

- All participants would be unpaid volunteers
- Possibility of less volunteers if longer
- Some participants had cognitive problems due to brain injury
- Possibility participants might leave early or have technical problems
- Time sufficient to cover the necessary research

As noted by researchers Nielsen Norman Group 'there isn't a golden number' of participants needed for user experience interviews which are like the planned co-design sessions (Nielsen Norman Group, 2021). The number of participants often determines the saturation point whereby the inclusion of more participants won't provide additional insights. As the emerging themes will have already been uncovered via the survey the sample size may not need to be very high. Nielsen Norman Group list some factors that affect the numbers needed including how experienced the recruited participants are and how structured the interviews are designed. Since the participants will be experienced in public transport and the planned structure of the co-design activities, four co-design sessions with 5 participants were planned.

Deep insights were necessary for this phase, and everyone would not be given a chance to speak if the participant numbers were too high. Three participants would be the minimum for diversity reasons so booking 5 covered the possibility of some participants becoming unavailable at the last minute.

4.5.1 Co-Design Recruitment

One hundred fourteen participants provided their contact email addresses for further contact, and these people were considered for an invitation to the co-design workshops. Most of the email addresses included a first name, and it was straightforward to ensure sufficient representation of females and males being invited. Some of these respondents used their employment email accounts, so it was easy to invite some Irish Rail staff and some employees of government agencies who completed the survey. In order to ensure appropriate representation of travellers with accessibility needs, the data was filtered by positive responses

to Q3 and Q4 concerning physical and communicative restrictions and some participants were selected for invitation. Invites were sent out in small batches to avoid overbooking, and each person was blind copied on the email to ensure their privacy. The message to them described the purpose of the event and some details, plus several dates and times for them to choose. As the workshop places filled up, invitations were sent to some other research students in the faculty to participate. Closer to the event dates, links to Microsoft Teams and Miro were shared with the people who accepted their invitation

4.5.2 Co-Design Facilitation

The literature review concluded some key strategies for facilitating in the co-design process. As mentioned by Sanders and Stappers (2012), one of the strengths of a layering approach (Fig. 14) used in co-design is that people get involved in the story initially when evaluating it and begin to uncover reasons for their evaluations. This may give more accurate results as people will be less inclined to provide impromptu responses without much thought.

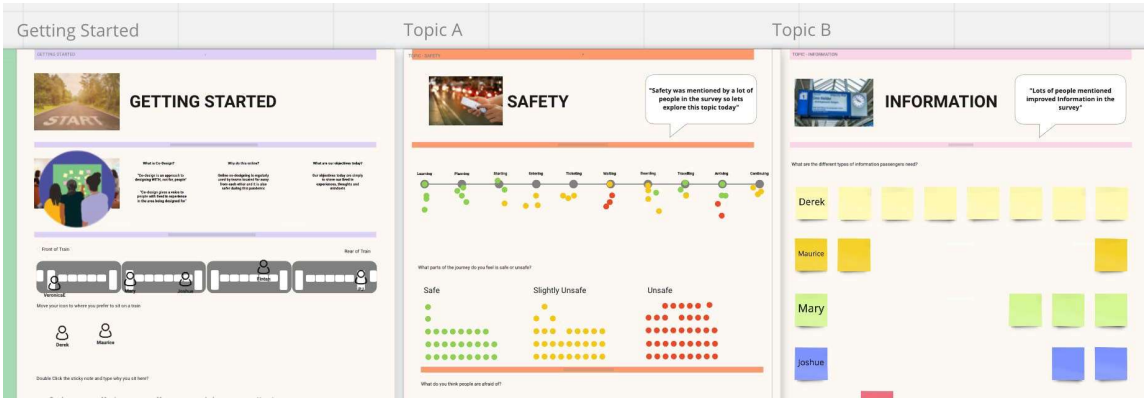


Figure 14: Layering the activities to promote story-telling

Researchers White et al (2021) used the instrument of a virtual co-design canvas, which encouraged an 'open and collaborative ideation' through a highly 'visual interaction' (White and Deevy, 2020, pp. 20). Sanders and Stappers note that participants need to be deeply involved in the problem so that their memories become sensitised and ready to contribute to their stories.

> …People will need to be prepared for these workshops…..so that they can become more sensitive to their awakened memories and associations and have the opportunity to gather stories that illustrate things they find interesting or worthwhile. (Sanders & Stappers 2012, p. 55)

Kelly Ann McKercher (2020) complements this approach with further recommendations for facilitators, noting the need to elevate and support the people with lived experience.

> Elevating the voices and contributions of people with lived experience involves supporting people to have their voices heard and taken seriously and beyond that, enabling people to author their own stories. (McKercher, KA, 2020 pp. 46)

McKercher states that we must be more interested in each other recommending to 'listen to how people feel' through 'generous listening', where the listener generates emotional safety through affirming people's experiences (McKercher, KA, 2020 P. 48). Facilitators need to be comfortable with uncertainty and complexity, practising curiosity is essential to deepen our understanding, and we can do this by asking better questions and displaying boundless curiosity and interest and avoiding any tendency to speculate and generally nurturing a safe space where we can connect with others (McKercher, KA, 2020, Ch. 3). McKercher provides a number of recommendations for facilitation as under (Table 9).

Table 9: Summary of the recommendations for facilitators (McKercher, KA, 2020 pp. 105-120)

Pre-empt barriers to participants, timing, resources etc
Widen inclusion by being mindful of participants' difficulties
Regular pauses for feedback and conversation
Being visual and interesting
Being flexible and not exerting too much control
Work in small groups
Give people plenty of time
Build ideas from the ground up

4.5.3 Generative toolkit for co-design workshop:

As the co-design session had some specific themes to be addressed, a series of exercises were required to be prepared in advance. These activities would require careful design to accomplish the objectives of the workshop and provide a friendly and productive environment for the participants who most likely will have never used the Miro application. Careful consideration was given to the experience and workflow of the workshops, including the modelling activities

around the three topics; Information, Security, and Accessibility, and the introduction and conclusion. Time was also required to sensitise the participants to be immersed back into the thought process involved in travelling.

Figure 15: Miro co-design workshop board

The virtual whiteboards as seen in fig 15 needed to be designed in a format that the participants would easily understand. The researcher facilitated the session, and the supervisory team acted as assistants offering mentorship and peer debriefing after each workshop. The facilitator aimed to give the participants complete freedom to contribute without anyone interpreting their views and recording on the board on their behalf. That is if they so wished. The facilitator also wanted to create an inclusive environment, did not want anyone to feel their opinions were superior or inferior to others and was mindful of the discussion on power differentials in co-design as mentioned in Section 2.3.1.

4.5.3.1 Co-design workshop – Introductions and Getting Started

The co-design workshop was broken down into stages, each taking approximately ten minutes. As the participants would arrive into the workshop this first screen (fig 16) would serve to remind the participants on the topic to be discussed.

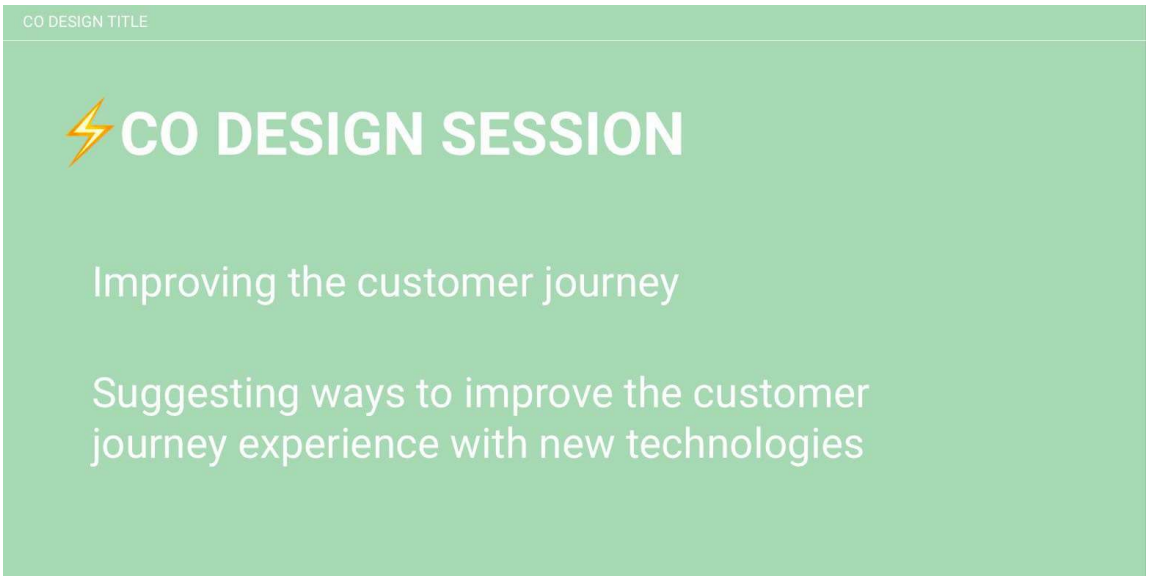


Figure 16: Introduction screen from co-design virtual whiteboard (Screenshot from co-design workshop board)

The next part of the introduction was an activity of introducing participants to each other. The facilitator planned to have each participant click on a sticky note and type a short intro under their name as shown in Fig 17. These names would be set up in advance so the participants

would not get confused. As Fig 17 shows, each entry was short and concise with each sticky notes only requiring a few words. This introduction activity would achieve several goals as detailed in table X. It would act as an instructive activity, teaching the participants some of the basics of Miro software. Also how to select a sticky note and how type onto it.

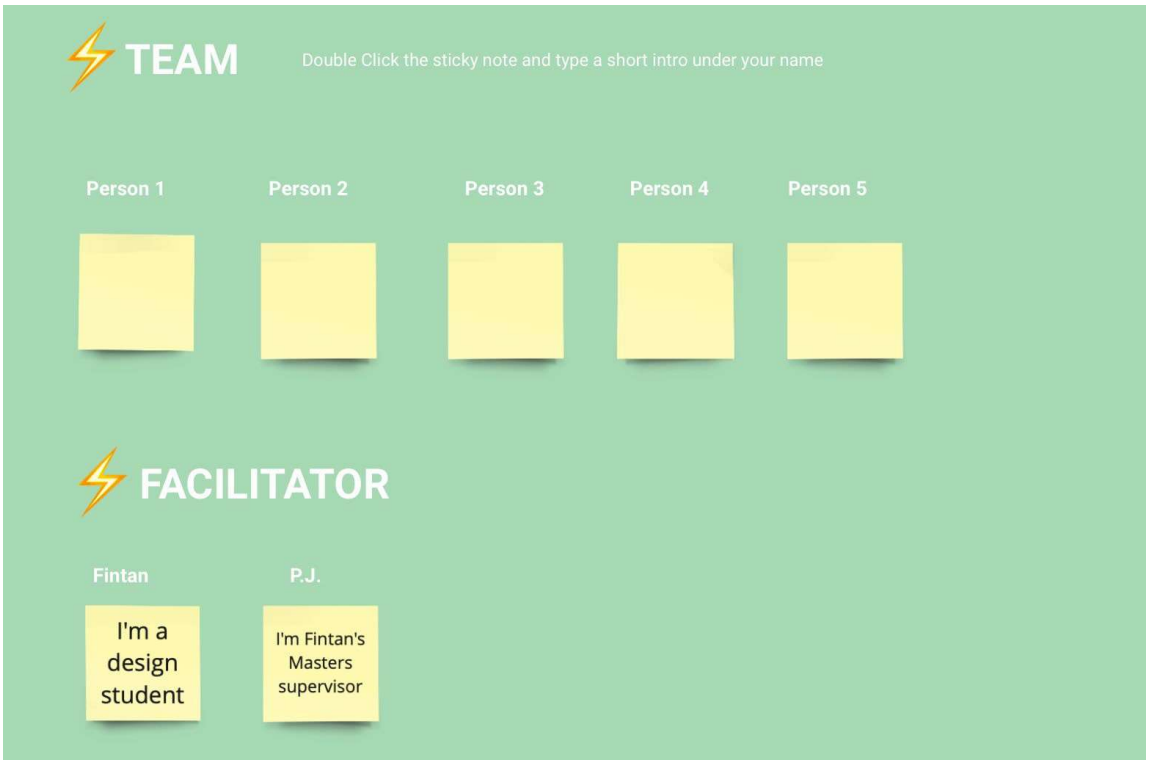


Figure 17: Introductions via a sticky note from co-design virtual whiteboard (Screenshot from co-design workshop board)

Table 10: Details on planned goals for the Introductions activities

Summary of Activity:	Introducing each other
Planned Duration:	10 minutes
Planned Goals:	To welcome all participants To introduce the researcher as a facilitator and the supervisor To find out about each other To fix any technical issues To get familiar with the virtual whiteboard To learn how to add text

Following on from this first activity, the facilitator planned a visual representation of the agenda for the session, including some bullet points for each of the activities. And following this, the facilitator offered a very brief explanation about the project to date, co-design, why we were doing this online together with the objectives of the study.

Due to the pandemic, many people restricted their travel, and some may not have travelled for several months, therefore before the co-design workshop started to look at the first topic, an activity was designed that would connect the participants with their past experiences and prepare them for an immersive look into their thoughts and feelings on public transport. This activity could be considered an icebreaker; however, it was a subtle means to awaken the participant's memories and associations and teach them how to move elements around the screen on the virtual whiteboard.

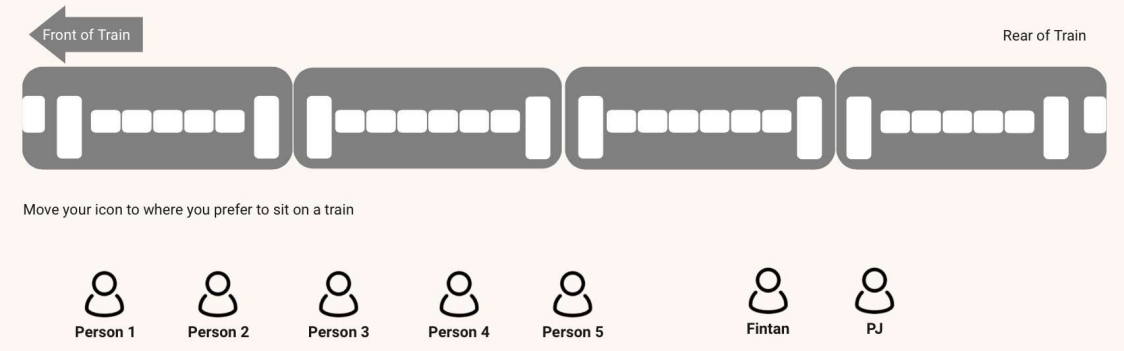


Figure 18: 'Getting started' Immersive activity to sensitise participants (Screenshot from co-design workshop board)

With a graphical representation of a 4 carriage train (Fig 18) and showing the direction of travel, the facilitator asked the participants where they preferred to sit? This the activity involved the participants dragging and dropping an icon with their name on it to where they chose to sit. Followed by this, the researcher would ask them why they decided this location? To generate some discussion and get the participants to reflect on their lived experiences, personalised sticky notes were added for each participant to type in their reasons for making this choice (Fig 19).

Figure 19: Sticky notes for participants to record their reasons for choosing where to sit (Screenshot from co-design workshop board)

Table 11: Details on planned goals for the Getting Started activity

Summary of Activity:	Getting Started
Planned Duration:	8-10 minutes
Planned Goals:	Sensitising the participants Enable self-documentation of thoughts Generate discussion Learn how to move elements on the virtual whiteboard Stimulate participants visually

4.5.3.2 Co-design workshop – Safety

To aid discussion on the first topic of 'Safety', a visual representation of the door-to-door journey defined by IDEO in the literature review (Chapter 2.1.1) was presented to the participants on the Miro board (Fig 20). The topic title is deliberately open ended, while most of the research up to this point showed travellers thinking about safety as 'personal safety', the co-design workshop wanted to avoid assuming that accidents was excluded from the discussion.

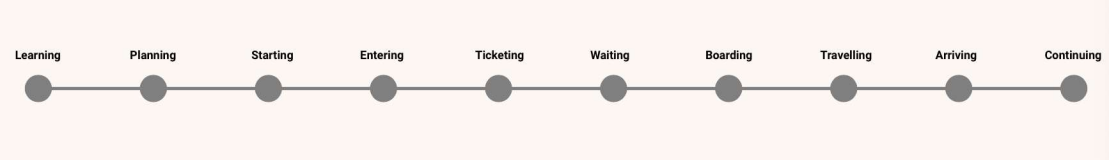


Figure 20: Door-to-door journey visual representation (Screenshot from co-design workshop board)

While all the participants would be very familiar with the door-to-door experience, the terminology used by IDEO for these stages might not be fully understood. As the stage of 'Travelling' is probably the easiest to understand, the facilitator planned to start with this stage when explaining the concept and then working backwards, explaining step by step to the very first stage. Then explaining the stages of 'arriving' and 'continuing', which are less ambiguous. Virtual sticky dots in Miro as Figure 21 below were generated for the participants, and each colour coded into versions for Safe / Slightly Unsafe / Unsafe.

Figure 21: Coloured dots for quantitative question (Screenshot from co-design workshop board)

The objective in this activity was for each participant to reflect on the different parts of the journey and think which parts are more or less safe than others. As they think about this they were asked to drag a sticky dot over to each stage of the journey choosing the one they felt described how safe it is or otherwise. This helps identify reflection, reveal underlying thoughts and stories, and show patterns and impact this topic has on them.

After completing this activity, participants were asked to reflect on what they think people are afraid of? Again there was rows of sticky notes on the board for them to record their thoughts. Purposefully, there were no names adjacent to these sticky notes as this topic may be sensitive to some of them or remind them of a bad experience in the past.

Table 12: Details on planned goals for the Safety activity

Summary of Activity: Planned Duration:	Safety (personal and general) 8-10 minutes
Planned Goals:	Quantitative data for each stage of the journey
	Qualitative brainstorming why people are afraid
	Generate discussion

4.5.3.3 Co-design workshop – Information

Rows of blank sticky notes were also generated for the activity on 'Information' to look at what different types of information passengers need. Unlike the activity for safety, no anonymity would be required, and each participant would have their own separate coloured row of sticky notes as this would be needed for the second part of the activity. The participants were asked what types of information they need in the context of the journey? What are they sometimes uncertain of? And what information would make the experience better? The participants were encouraged not to worry about being original so they would not need to read everyone else's idea before posting their own.

After spending a few minutes filling in sticky notes, recording thoughts and discussing thus topic, the participants were then asked to drag and drop each of their own notes onto a grid of two sides with 'essential' or 'nice to have' as shown in Figure 22. This requires them to reflect on their output and decide some level of priority with some conferring with the other participants encouraged.

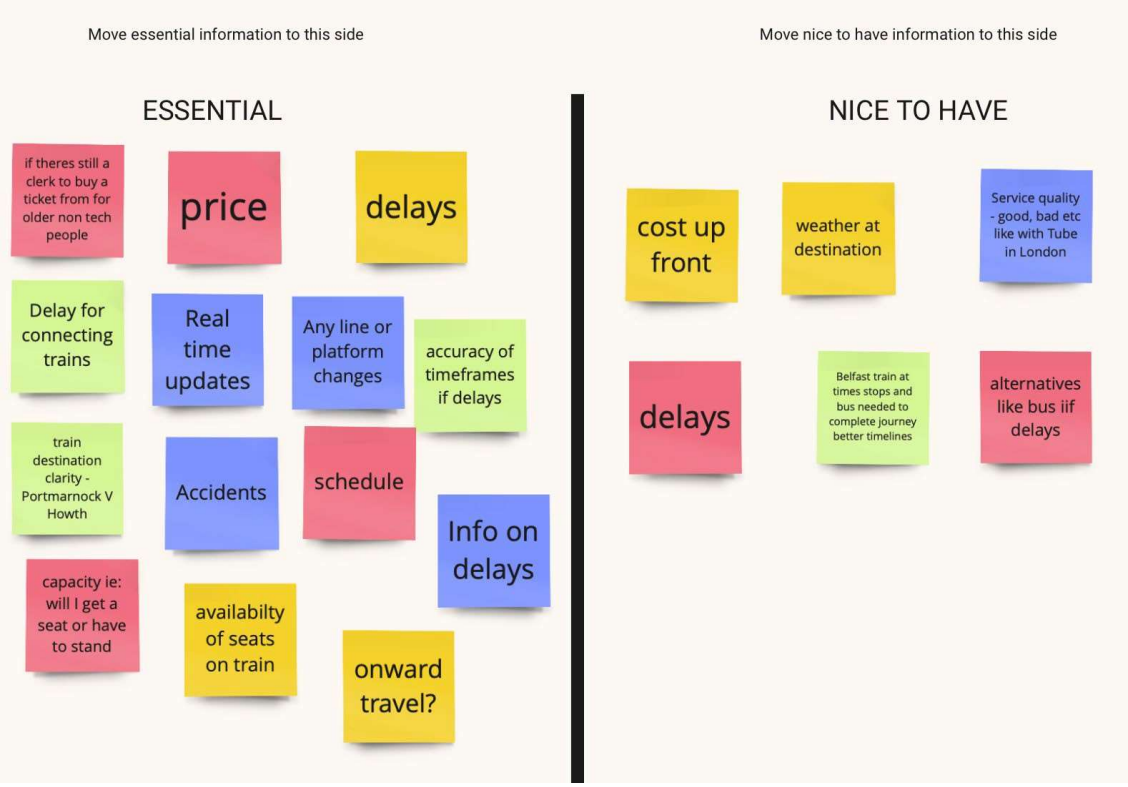


Figure 22: Sorting information types into 'essential' or 'nice to have' (Screenshot from one workshop)

Table 13: Details on planned goals for the Information activity

Summary of Activity:	Information (all types)
Planned Duration:	8-10 minutes
Planned Goals:	Qualitative brainstorming of what info is needed
	Participant-coded into 'Essential' and 'Nice to have'

4.5.3.4 Co-design workshop – Accessibility

The visual representation of the ten stages of the door-to-door journey were used again for the participants to consider which parts of the journey participants feel were accessible for them or others. From a choice of coloured dots for a quantitative assessment: Accessible, Slightly Difficult or Not Accessible, they considered each of the stages in the context of general accessibility. Since everybody does not have accessibility needs the groups were asked to think about everyone's experience for this. Following on from this activity, the question 'how could

the journey be more accessible for everyone' was asked to brainstorm ideas and identify pain points.

Table 14: Details on planned goals for the Accessibility activity

Summary of Activity: Planned Duration:	Accessibility (all types) 8-10 minutes
Planned Goals:	Quantitative data for each stage of the journey
	Qualitative brainstorming about helping make travelling easier
	Generate discussion

4.5.3.5 Co-design workshop – Autonomy

The last activity of the co-design workshop aimed to consider the area of 'autonomy' asking the group to reflect on all the feedback contributed and think theoretically about how much of a difference that improvements discussed during the session would make. Could these changes make people feel more independent and feel greater autonomy?

Table 15: Details on planned goals for the Autonomy activity

Summary of Activity:	Autonomy
Planned Duration:	8-10 minutes
Planned Goals:	Quantitative data on the research question

Chapter 5: Design Research - Results

The research was designed to study the following research questions; What interactive systems should be designed to improve experience and autonomy for Irish Rail's customer's door to door journey, and how can user centred design frameworks assist Irish Rail to meet this? Following the online survey and the co-design workshops, the main outputs from both are compiled in this chapter with commentary and analysis. The conclusions are outlined further in the follow chapter (Chapter 6) and more detailed research data relating to this may be found in the Appendices. All outputs were subject to peer debrief for reliability and validity.

5.1 Key Insights from survey

The online survey received 316 responses and the vast majority of questions were answered with only a very small number of questions were skipped. A number of major themes emerged and the summary outputs from the survey, collated by theme are as follows in table 16;

Table 16: Key insights from survey vis-à-vis the main emergent themes

Information	When delays happen, 57% don't feel sufficiently informed. The majority of travellers (57%) feel it is difficult to compare the advantages of train travel with other modes of travel. When planning a new trip, 24% of travellers don't check if there is a train service serving it. 14% of travellers do not have all the information they need before setting out to travel.
Accessibility	6% of travellers do not feel independent enough. 4% have some physical restrictions on their mobility to travel on public transport. 10% of travellers encounter sensory or communication restrictions when travelling on public transport. At the station, 14% do not find it easy to access and navigate. Accessibility is a concern for travellers at all stages of the complete customer journey.
Personal Security	55% have experienced safety and security concerns. Personal safety is a concerns at all stages of the complete customer journey. While the train is in motion, 47% of travellers continue to be concerned with safety and security.
Ticketing	Close to one-fifth of people purchase their tickets offline.

	The decision whether to buy online/ticket office/ticket machine etc. is mainly influenced by the perceived convenience and cheapest price
Comfort	67% of travellers might prefer a quieter train even though it was slower
Facilities	Almost half the travellers that need to park (car, bike, scooter) find it difficult
Anxiety	As the train arrives, there are several things in the mind of travellers which may give rise to anxiety, such as lateness, getting a seat, their safety, if they are on the correct train, and if they will be able to get on safely. As the train arrives at the destination, there are many thoughts that can give rise to anxiety, e.g. getting off, personal belongings, unruly passengers, making connections, getting out of the station, etc.

5.1.1 Learning Stage

Learning Stage Summary Findings

- 26% feel that information on the company is not easily obtained (Fig 22).
- 44% feel it is difficult to compare the advantages of train travel with other modes of travel (Fig 23).

Looking at the very origins of the door-to-door journey or the steps in advance of taking a trip, the researcher asked if the respondents thought that information on Irish Rail is easily obtained, 26% of respondents did not believe so, Fig 23.

Further to this, 43% of respondents stated that they did not think it is easy to compare the advantages or disadvantages of train travel with other modes of travel, Fig 24. There is a lot of room for improvement regarding information for travellers, which can be explored further in the study.

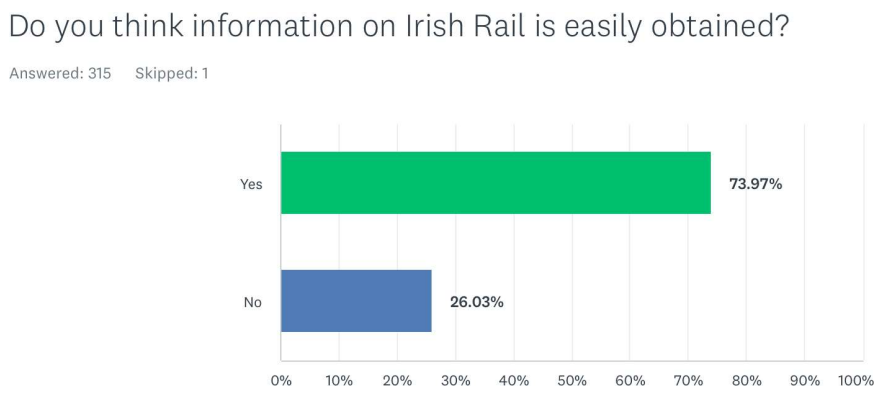


Figure 23: Is information easily obtained?

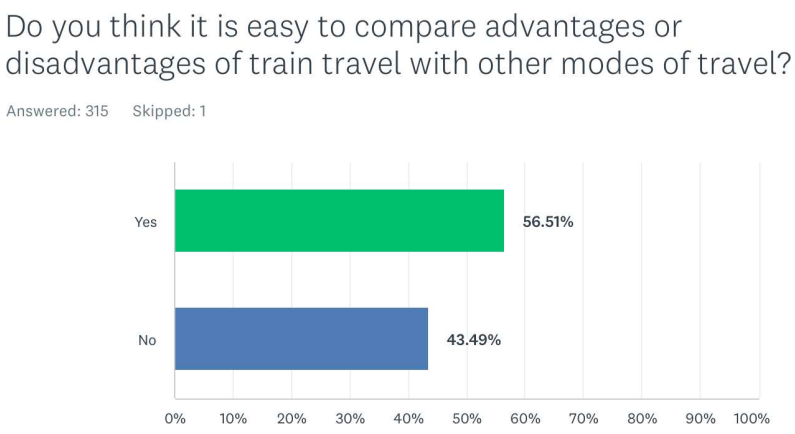


Figure 24: Finding Information comparing train travel with other modes

5.1.2 Planning Stage

Planning Stage Summary Findings

- Almost all travellers (95%) use the internet or smartphone apps to find timetables and prices (Fig 25)
- When planning a new trip, 24% of travellers don't check if the is a train service serving it (Fig 26)

Looking at how travellers find out information such as train timetables and prices, almost everyone uses the internet or smartphone apps (95%), but a quarter of the respondents also spoke to employees either at the station or via phone (Fig 24). However participants were recruited via social media and email so this high percentage may not be surprising.

Since the study is focused on technology, this is a very positive affirmation of using technology for the provision and accessibility of information supporting the traveller's needs surrounding the Learning stage of the customer journey. The study confirms this is expressly needed because respondents have indicated that 14% feel that they don't have all the information they need before starting on their journey.

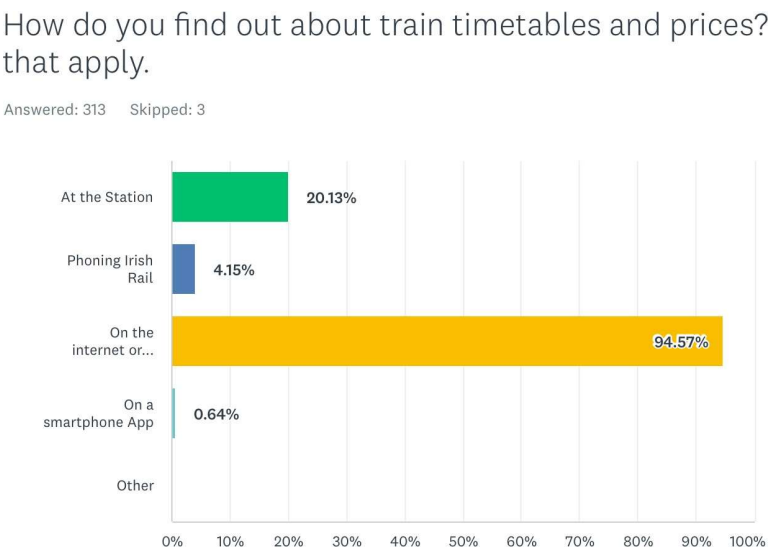


Figure 25: How to get timetables and prices

Diving deeper into the information needs of travellers have when planning a new trip'. The question in Fig 26 was designed to consider a trip the travellers were not already familiar with. Almost a quarter of respondents responded that they don't check, and this opens a number of questions about whether the travellers just don't want the rail option or whether this type of information is not easy to access?

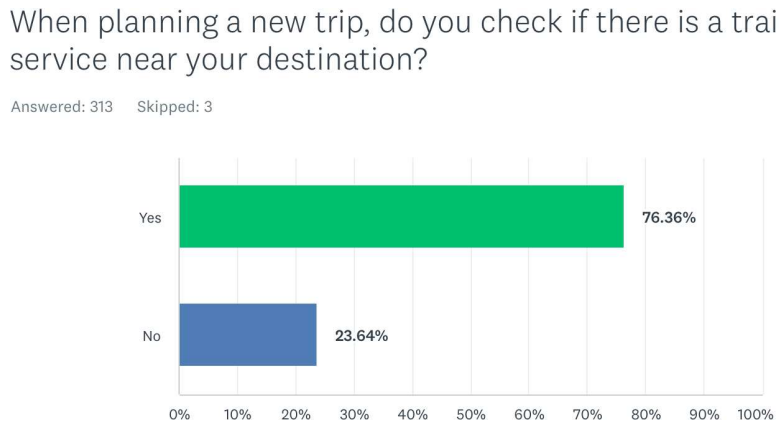


Figure 26: When planning a new trip, do you check the train?

5.1.3 Starting Stage

Starting Stage Summary Findings

- 14% of travellers do not have all the information they need before setting out to travel and clearly improvements are required in this area (Fig 27)
- Most travellers are thinking about Punctuality, trip planning and capacity (Fig 28)

On starting a journey there are many different things on the traveller's minds which are determined via open questions in the survey. 14% of the respondents did not feel that they had all the info they needed.

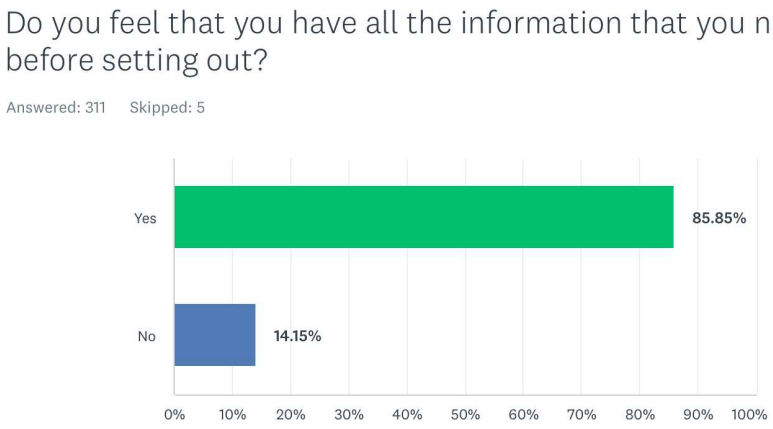


Figure 27: Do you have all the information you need before setting out?

Punctuality, ETAs, delays, trip duration, capacity, comfort, platform numbers, accessibility issues etc. are uppermost in their minds, as indicated in the diagram below Fig 28. All of the topics mentioned in the survey responses are compiled and categorised in the following main areas; information, comfort, safety and accessibility which will be analysed more closely as the study progresses. For some items, it may not be possible to make any improvements via technology, and these will be noted for further research outside of this study.

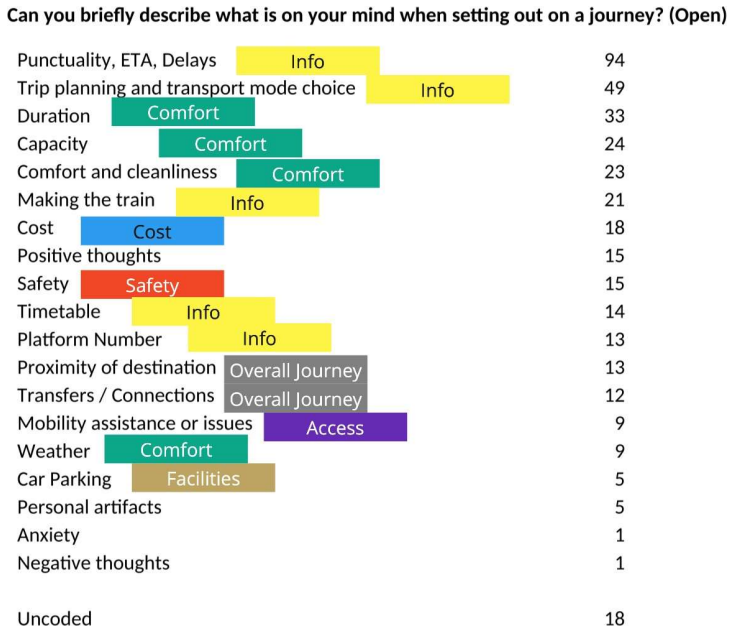


Figure 28: What is on your mind when setting out?

5.1.4 Entering Stage

Entering Stage Summary Findings

- At the station, 14% do not find it easy to access and navigate (Fig. 29)
- Almost half the travellers that need to park (car, bike, scooter) find it difficult to (Fig. 30)
- A large majority have the need for information needs in their mind as they enter the station (Fig. 31)

After the travellers started out on the door-to-door journey, they would ultimately arrive at the station to begin the rail portion of their trip. The survey asked the participants if they found the station to navigate on arrival, and by and large, this posed no issues to the majority of travellers. However as shown in Fig 28, a significant amount of respondents, 14%, did not find it easy to access/navigate, which is a higher percentage than the respondents who revealed they had

sensory or physical restrictions, and this may suggest that there a need for improvement in general accessibility and ease of navigation within the stations themselves.

As revealed earlier in the survey, many travellers arrive by bike, car, scooter, etc. Many of these find it difficult to find parking at the station (Fig 30). While 33% of the respondents did not need parking, 22% did and found it challenging to park, while 44% did not have any parking problems.

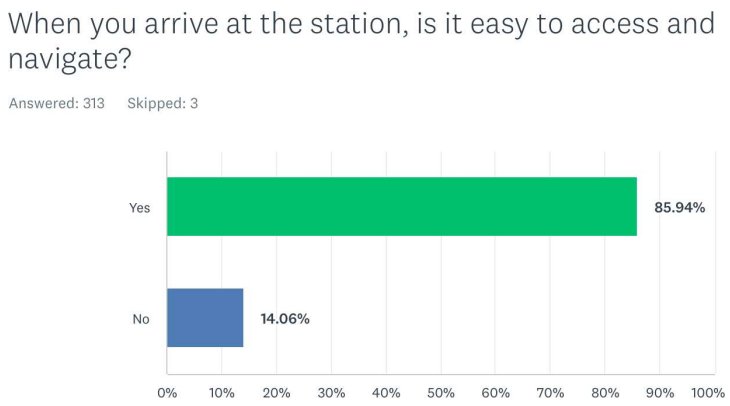


Figure 29: Is the station easy to access and navigate

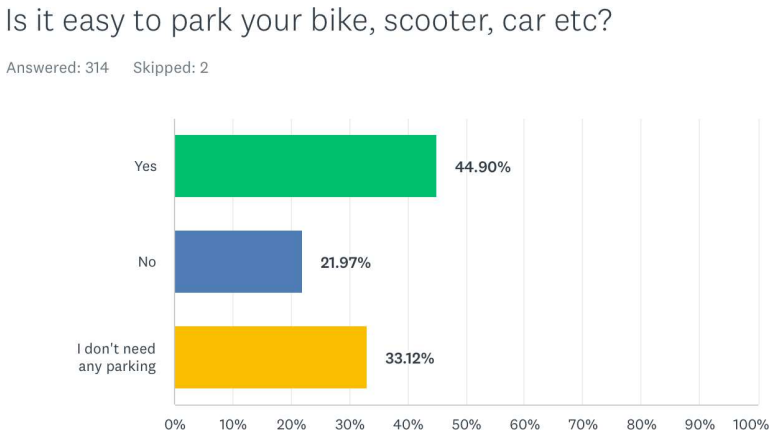


Figure 30: Is parking easy?

An open question was used to find out what was on the traveller's minds when entering the station, and this revealed an extensive range of thoughts (Fig 31). The vast majority of travellers were thinking about what platform their train would arrive or depart from, what time it would

arrive or depart and whether there were any delays. Along with this type of information, travellers were concerned with navigating the station and making their trains. Many were also thinking about their comforts such as shelter, seating and heating and facilities such as refreshments and toilets.

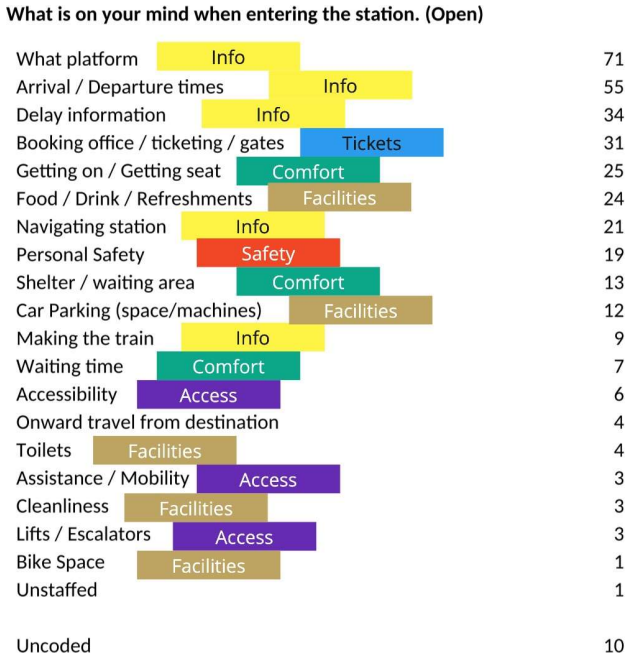


Figure 31: What is on your mind when entering the station?

All the participant's thoughts are compiled into the figure above and coded/categorised into the topics, information, ticketing, comfort, facilities, accessibility, and safety.

5.1.5 Ticketing Stage

Ticketing Stage Summary Findings

- Close to one fifth of people purchase their ticket offline (Fig 32)
- Although 97% of travellers are comfortable with technology, a considerable amount of people purchase at the ticket office / ticket machine. Overall 7% don't find purchasing tickets easy (Fig 33)
- The decision whether to purchase online/ticket office/ticket machine etc is mostly influenced by the perceived convenience and cheapest price (Table 17)

The next stage of the door-to-door customer journey is ticketing which involves purchasing via ticket offices, vending machines or in advance on the internet and then gaining access to the platforms via ticket gates and validators. The survey asked the participants how they purchased their tickets to understand how much a part this area was in the context of the complete journey (Fig 31). Unsurprisingly the respondents usually obtain their tickets in advance either online 34% or with commuter tickets 32% and some purchase in advance at the ticket office 1%. Travellers purchase on the day from the ticket office 8% or at the ticket vending machines 10%. The remaining travellers, 15% mentioned state social welfare travel passes, Irish Rail employee passes or Leap smartcards.

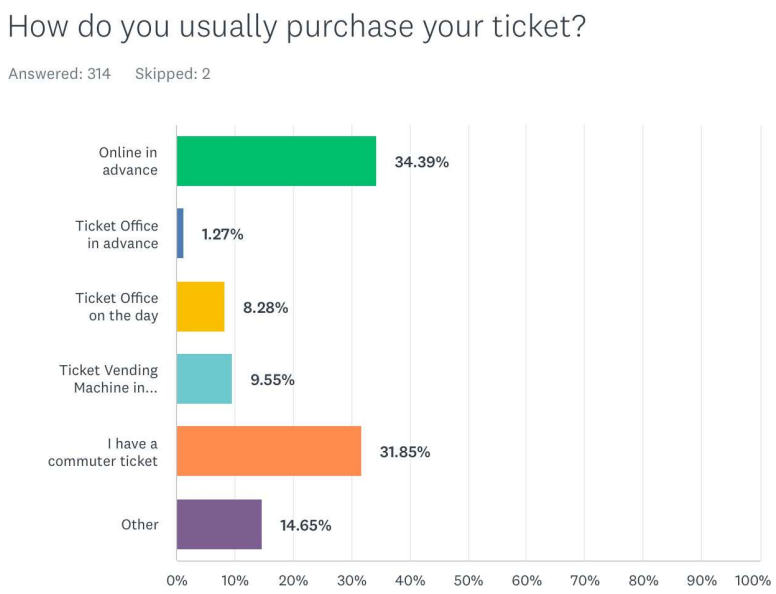


Figure 32: How do you purchase your ticket?

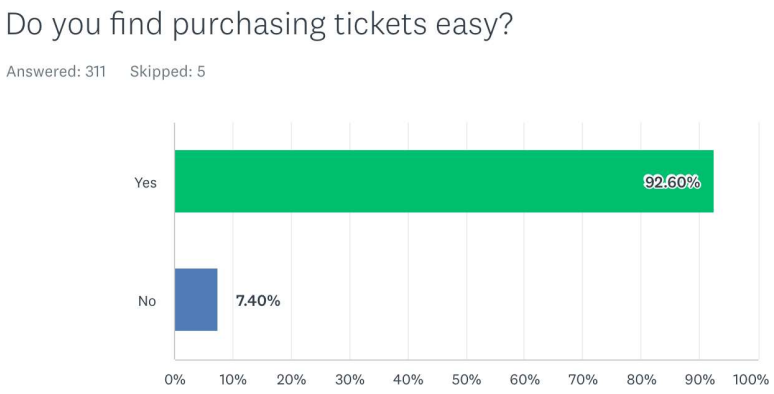


Figure 33: Do you find purchasing tickets easy?

Most of the respondents selected their ticket purchase option because they felt it was most convenient for them, and this was especially true for those purchasing in advance (Table 16). Many of those buying on the day at the ticket office did so because the ticket option they wanted was not available online. Respondents who purchased commuter tickets did so because they were cheaper, more convenient or because they are employer-provided.

Purchasing ticket vending machines were popular mainly because they 'did not have to speak to anyone'. The self-service model for ticketing is the most popular among the respondents; however, a significant portion opt for in-person transactions, particularly whereby additional ticket options are available. When cross-referencing the number of respondents that are comfortable using technology (97%) with those who find it easier to purchase at the ticket office on the day or in advance (10%), there may be sufficient numbers finding the ticket office easier, in which case there may be merit in simplifying online ticket purchasing.

Table 17: Primary motivator for choosing this method of purchase

Ticket office on the day	Ticket Office Advance	Online in advance
Easier Ticket not available online / machine Unable to use website Not a frequent traveller	Ticket not available online	Easier Cheaper Avoid queues Guarantee seats

Commuter ticket	Ticket Machine	Leap Card
Convenience Cheaper Provided by employer	Don't have to speak with anyone Convenient Easier Leap card top-up No Booking office	Convenient Cheaper

5.1.6 Waiting Stage

Summary Findings Waiting Stage

- 55% have experienced safety and security concerns (Fig 34)
- Anxiety levels are high for a number of reasons (Fig 36)
- Station design improvements, improved information and staffing would improve the experience waiting at the station for almost everyone (Fig 35)

Following on from travellers either purchasing their tickets or gaining entry using an existing ticket, in many cases, they must wait for the service to arrive. The survey asked the participants what was on their minds as they waited and most respondents mentioned thinking about whether the train would be late or not (Fig 36). A similar number of people said thinking about capacity, i.e. whether there would be seats available for them. Some respondents mentioned anxiety in this respect. Travellers already with pre-booked seats were thinking or felt anxious about whether another passenger would take their seat. Travellers felt anxious about several other things, such as their safety, whether they were on the right platform or how they would find their seat when the train arrived. Accessibility worries were also in the respondent's minds, mainly being able to board the train and difficulties hearing or understanding the public address announcements. Some respondents also mentioned comfort issues such as a lack of shelter from the elements and issues relating to the availability of toilets and refreshments.

The survey took a deeper look at personal safety as the travellers waiting for their service to arrive and be boarded, asking if safety and security are a concern as they wait (Fig 34)? To this, 46% said no, it is ‘not a concern, however, 15% said ‘yes often’, and 39% said ‘yes sometimes’. The majority of travellers feel personal safety is a concern, and this area is noted for further research within this study.

Pre-empting the traveller's need for information at this point in the journey, the survey question was included ‘how do you keep informed about your train as you wait? 65% of respondents used the displays in the stations, 47% mentioned the announcements, and 48% used the internet and smartphone apps. 20% used social media (Fig 35).

Looking at solutions to help travellers as they waited for their train, the survey asked the open question 'is there anything that would make waiting in the station better for you', which yielded many suggestions (Fig 37). Participants mentioned better shelter, better lighting and heating, better seating, better toilets and cleanliness and improved availability of refreshment options. They said improved information and announcements, more staff, assistance and better security would also lessen the anxiety experienced. It is also clear that improved station design and staffing could significantly improve the journey for most travellers. In addition, improving the amount, accessibility and accuracy of information would also improve the experience.

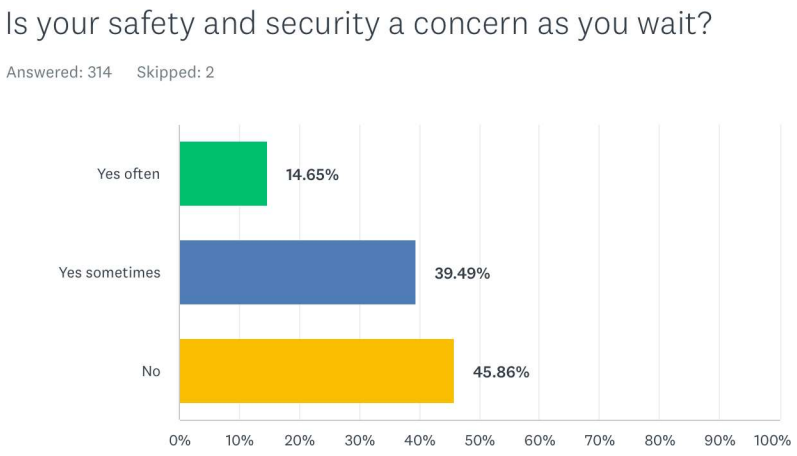


Figure 34: Safety and Security while waiting

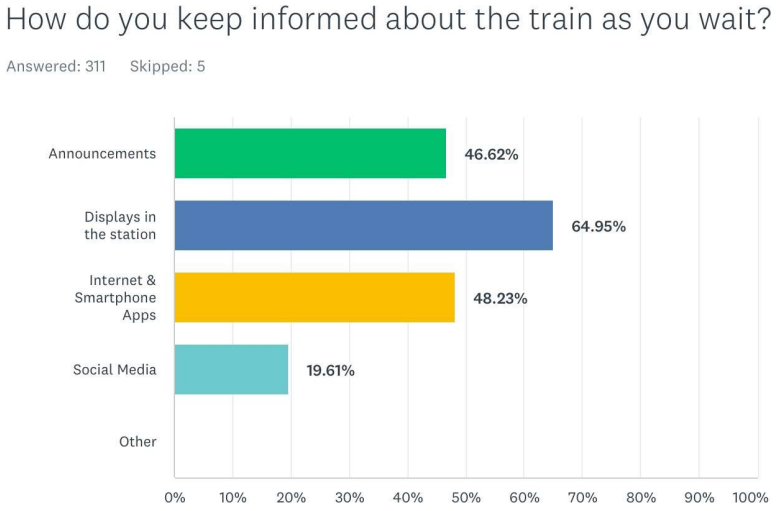


Figure 35: How do you keep informed while waiting?

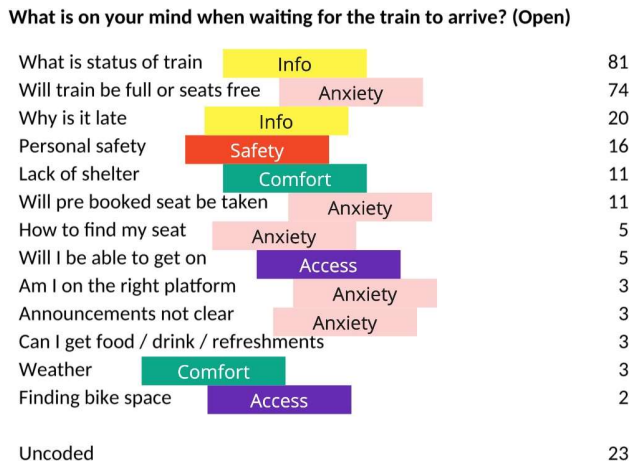


Figure 36: What is on your mind while waiting for the train?

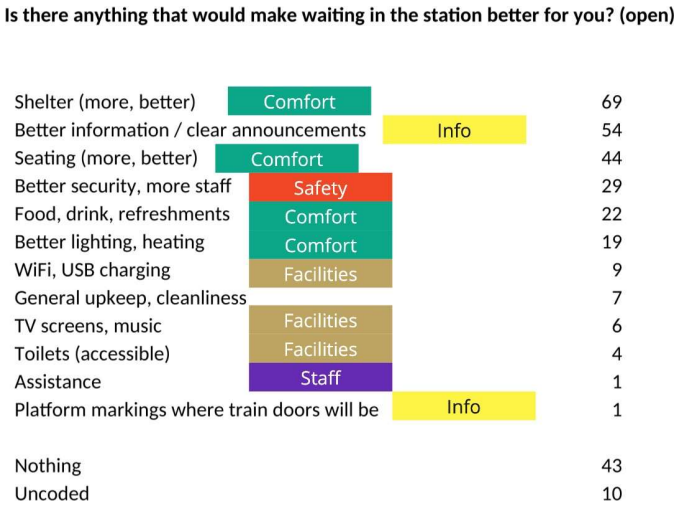


Figure 37: What could make waiting better?

5.1.7 Boarding Stage

Boarding Stage Summary Findings

- Generally, most travellers are anxious about obtaining a seat in a safe place as the train arrives, and 8% are concerned with the accessibility aspect of entering the train (Fig 38)
- As the train arrives, there are several things in the mind of travellers which may give rise to anxiety, such as lateness, getting a seat, their safety, if they are on the right train and if they will be able to get on safely (Fig 39)
- Physical assistance, improved information & wayfinding, and some consideration/courtesy from other travellers would make boarding easier (Fig 40)

Considering that some travellers may have difficulties boarding trains the survey asked if they 'felt confident when boarding', to which 8% of the respondents said that they did not (Fig 38). This response seems to go against the level of anxiety expressed in the question asking the travellers what was on their mind? (Fig 39); however, a follow on the open question attempts to uncover any areas for improvement. While a significant number of respondents said 'nothing'. Many others mentioned orderly boarding and egress, diagrams showing busy locations of the train, narrower gaps, and better signage for carriages and seat numbers (Fig 40).

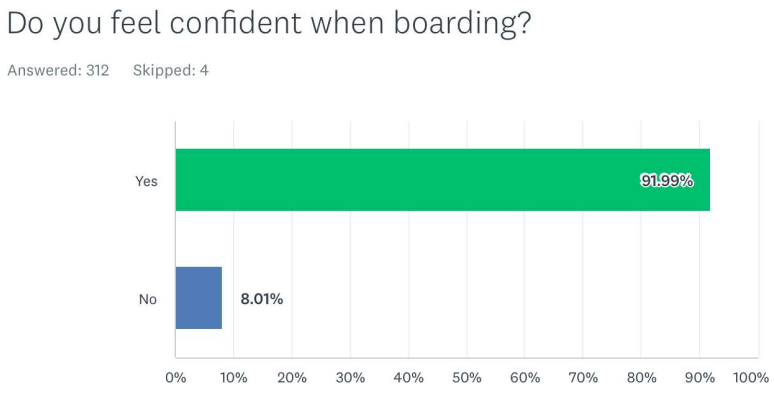


Figure 38: Do you feel confident when boarding?

As your train arrives what is on your mind? (Open)

Figure 39: What is on your mind as the train arrives?

Is there anything that would make boarding easier for you? (Open)

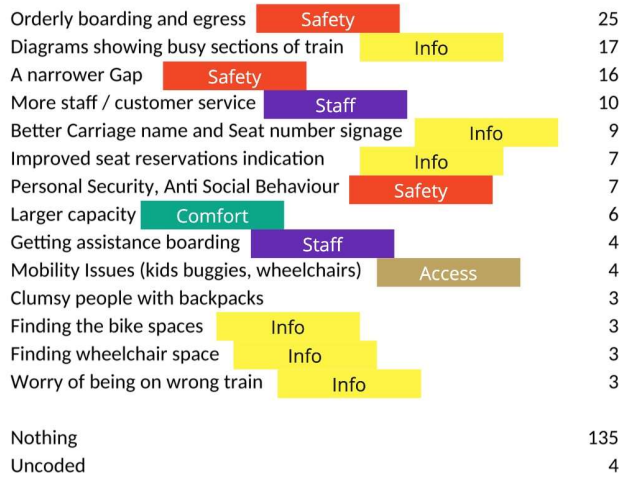


Figure 40: What would make boarding easier for you?

5.1.8 Travelling Stage

Travelling Stage Summary Findings

- When delays happen, 57% don't feel sufficiently informed (Fig 41)
- While the train is in motion, 47% of travellers continue to be concerned with safety and security (Fig 42)
- 67% of travellers might prefer a quieter train even though it was slower (Fig 43)
- As they travel most travellers are focused on themselves (reading/working/looking out window) though safety, accessibility and timekeeping are uppermost in other travellers minds (Fig 44)
- Travellers noted the main improvements to the travelling stage as improving safety, improving communication & info, improving capacity, comfort and accessibility (Fig 45)

The next stage of the door-to-door journey is the actual travelling on the service, and the survey asks what is on travellers' minds as they travel. A large portion of the respondents indicated they are 'switched off' and focused on themselves, playing games, sleeping or entertaining themselves, and studying or working on computers (Fig 44). However, there are many mentions of personal safety and anxiety about missing a stop or a connection, or if the train is running late 57% say they don't feel sufficiently informed (Fig 41)

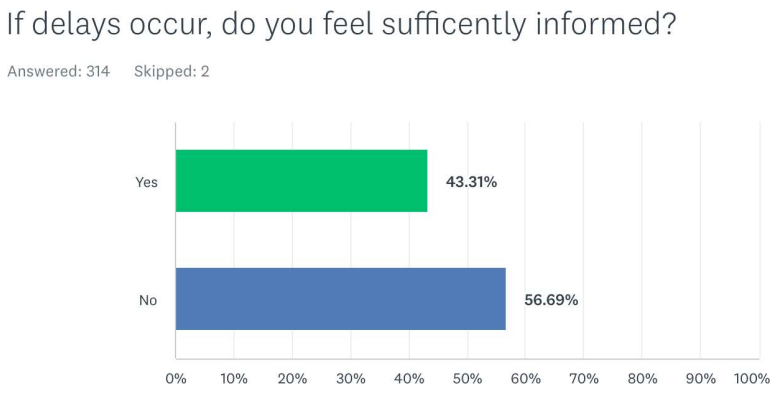


Figure 41: Are you informed when delays occur?

Pre-empting the safety aspect, the survey questioned travellers on their feeling of personal safety during the trip. They were asked if 'safety and security were of concern while travelling'. 47% of the respondents answered 'yes' that it is indeed a concern (Fig 42). From the researcher's experience, the survey also asked if 'delays occur, do you feel sufficiently informed' to which most respondents said 'no' they were not sufficiently informed. With 57% of travellers feeling this way, improvements in managing delays are needed for occasions when things do not go according to plan.

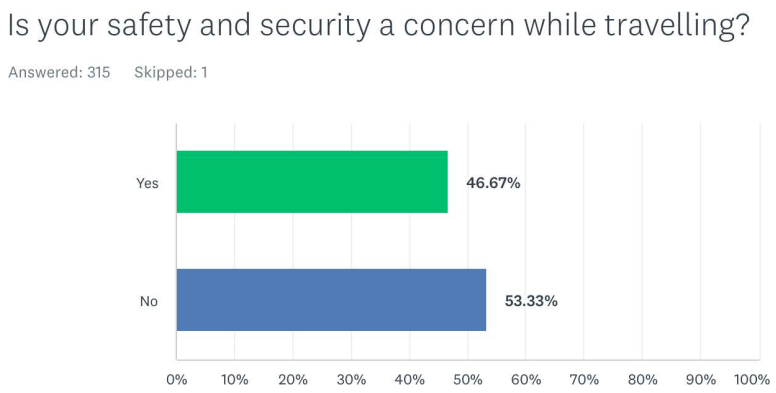


Figure 42: Is personal safety 'a concern' while travelling?

The survey included a question that showed whether speed or comfort was more important. Asking the participants, 'if train A was slightly quicker but very busy and train B was slightly slower but very quiet, generally speaking, which would you take?'. 33% of respondents opted for the quicker train, with 67% opting for the slightly slower one (Fig 43). Clearly, travellers need to have information on how busy or otherwise trains are and capacity information to choose a train service that is the most suitable for their needs.

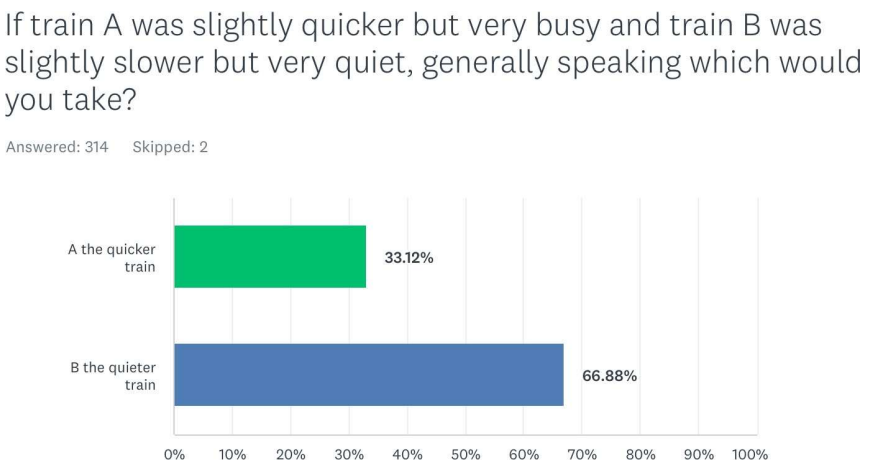


Figure 43: Speed vs Quiet, which train would you take?

The respondents provided many different suggestions via an open question on how to make travelling more enjoyable, some of which would be relatively easy to implement (Fig 45). Others would take considerable investment when public transport returns to peak capacity. Travellers mentioned improving security and staffing on board, tackling anti-social behaviour and emergency contacts. They suggested improved information and communication to inform about the status of the train, its location and the distance to the next stop. Improved Wi-Fi access, charging points, cleanliness and marking of pre-booked seats were also noted. Some of the respondents also mentioned refreshments and food ordering. For comfort, some travellers asked for increased capacity on the trains with improved heating and air conditioning and TV screens showing news channels.

What is on your mind as you travel? (Open)

Figure 44: What is on your mind as you travel?

Is there anything that would make travelling more enjoyable? (Open)

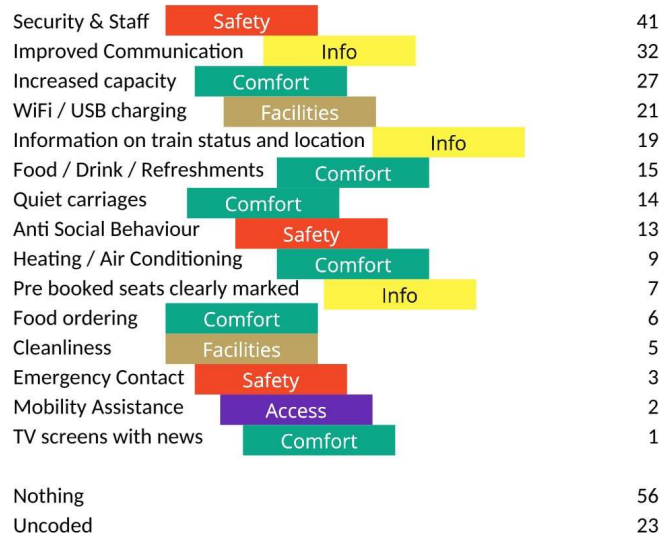


Figure 45: What would make travelling more enjoyable?

5.1.9 Arriving Stage

Arriving Stage Summary Findings

- As the train arrives to the destination there appears to be a lot of thoughts that can give rise to anxiety e.g. getting off, personal belongings, unruly passengers, making connections, getting out of station etc. (Fig 46)

As travellers complete the rail part of their journey and arrive at their destination station, they have many things in mind (Fig 46). Many are checking onward connections and thinking of how they will get off the train safely and exit the station. There appears to be a level of anxiety experienced as travellers gather their personal belongings, leaving with pushing crowds, negotiate the platform gaps, and get their tickets ready for validator gates. In contrast, others are just relieved this part of the journey is over.

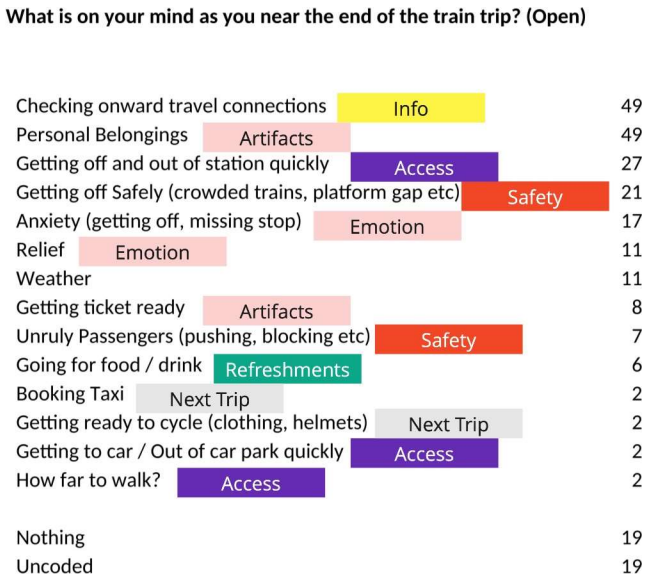


Figure 46: What is on your mind at the end of the train trip?

Arriving at the final destination, the respondents feel happy or relieved that the journey is over and getting on with whatever activities they intended (Fig 47). If the journey was long or troublesome, they are feeling tired or annoyed.

Figure 47: What is on your mind as you arrive at the final destination

5.1.10 Continuing Stage

Continuing Stage Summary Findings

- The door to door journey involves multiple modes of transport (Fig 48)
- There are a wide range of needs many of which may be outside the remit of this study (Table 18)
- As the travellers arrive at their final destination most passengers are happy, some are tired, annoyed, puzzled or anxious (Fig 49)

For most travellers, their next step is walking on to their final destination but many others are travelling there by car, bike, bus or tram which again re-enforces the complete customer journey as being much wider than just the train trip (Fig 48).

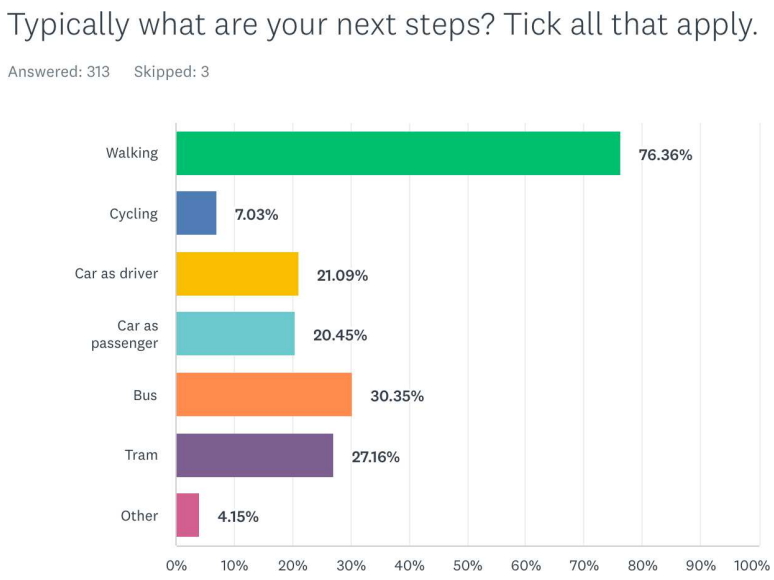


Figure 48: After the train what are your next steps?

The final question on the journey in the survey asks the participants if 'there is anything that would improve your general mobility and freedom' as they reflect on a typical journey (Table 18). The main item is improved and more accurate information which has been mentioned throughout the surveys. Increasing capacity is also very much important for the respondents. They also ask for improved integration with other modes of travel which suggests that the door-to-door journey is more important to travellers than just the rail aspect on its own. Safety and security also have been a theme throughout the survey and this is also given high priority from the numerous replies.

Table 18: Improving general mobility and freedom (summary responses)

Improved information	Assistance from staff	Courtesy from other passengers
More accurate information	Improved reliability	Faster trains
Improved integration with other modes of travel	More trains, more stations	Cheaper tickets
Personal safety and security	Easier access, lifts etc	Improved Station Design
	More bike and car spaces	

Accessibility and assistance are also mentioned by many respondents to be something that would improve general mobility and freedom. Many respondents, however, chose to answer this question with 'nothing' being either reasonably content with their door-to-door journey or

possibly having a lower expectation and acceptance from it thus not having any suggestions to improve.

Appendix B, shows an unfiltered view of all the responses to this question. As can be seen, there is a wide range of suggestions many of which would not be either in Irish Rail's remit to improve or outside of this study. The complete unedited list is shown to understand the complexity of these users' needs.

Figure 49: What is on your mind as you arrive at your final destination

5.1.11 Additional Questions relevant to the Research Questions

Summary Findings in the context of the research questions

- Technology is not a barrier for most travellers 97% of which say they are comfortable using smartphones and apps (Fig 51)
- The customer journey involves many different modes of travel (Fig 52)

As the topic of the study involved improving autonomy, the researcher posed the question on travellers feeling sufficiently independent in mobility options which resulted in a positive response from a large majority 94% (Fig 50). However the researcher felt this question could have yielded a somewhat more nuanced response if they had been asked this question in person where some context or explanation behind the reasoning for both the question and the participants answer could be given. This would be addressed during the co-design workshops.

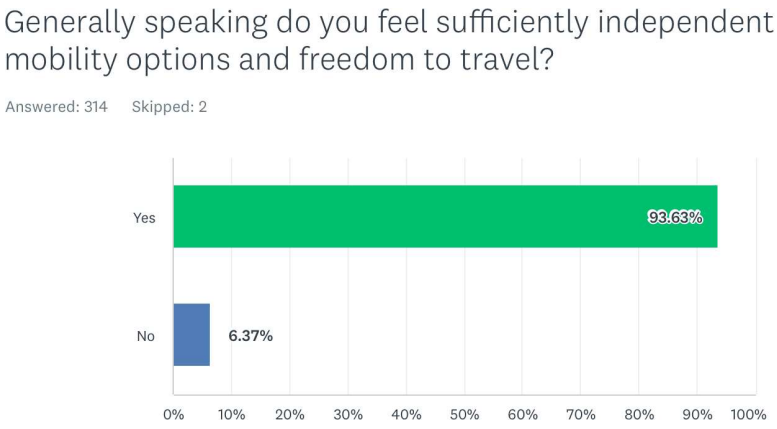


Figure 50: Do you feel independent in travel?

Since the topic also involves the potential introduction of new technology, the researcher also asked if the respondents were comfortable using smartphones and smartphone applications. Again only 11 responses out of 315 indicated that they were not comfortable using this technology (Fig 51). This gives an assurance to the researcher that there are no barriers to implementing any improvements to the complete customer journey in terms of adoption by the traveller. However, with 3% not being comfortable, it will be important to ensure any new technologies are easy to use by all. As previously mentioned, invitations for this survey were

sent via email and social media so most completing this question would be comfortable with technology and separate research should be undertaken addressing this point.

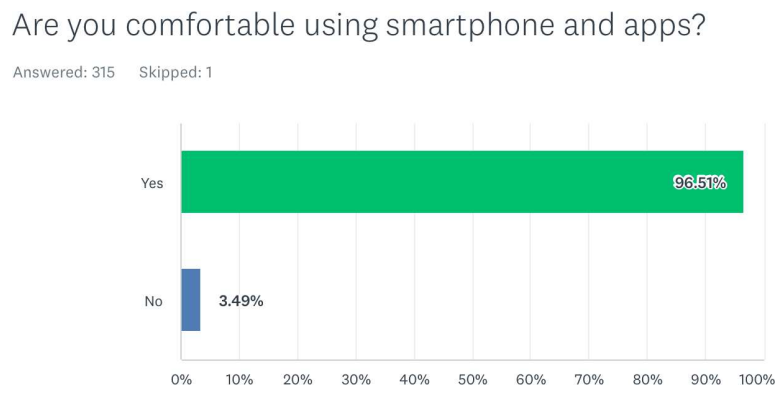


Figure 51: Are you comfortable using smartphones?

For the context of researching a 'complete customer journey' the researcher asked the participants what additional modes they use in their 'door-to-door trip' and this yielded quite a diverse set of modes as shown below and this would indicate that the train trip is just part of their door to door journey and this should be given even full consideration (Fig 52).

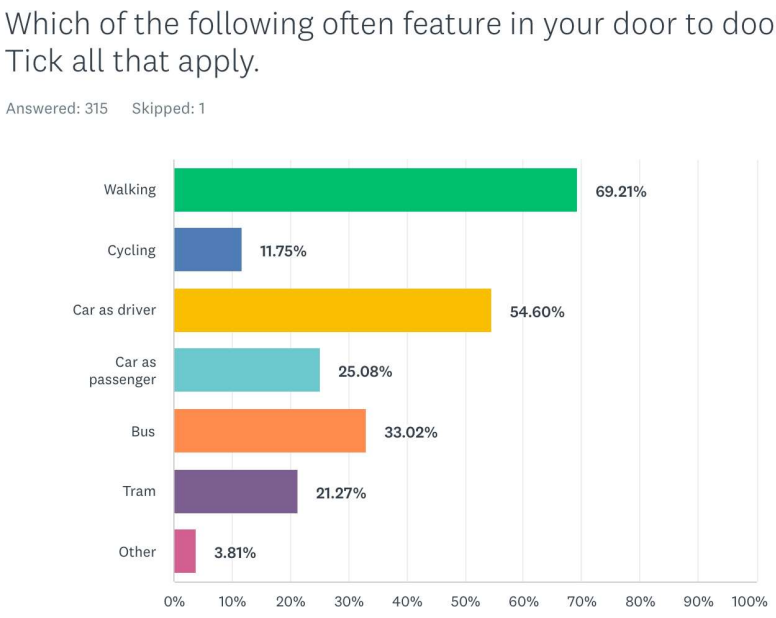


Figure 52: Multi-modal journeys

5.1.12 Additional Questions based on general Accessibility

Accessibility Summary Findings

- 4% have some physical restrictions in their mobility to travel on public transport (Fig. 53)
- 10% of travellers encounter sensory or communication restrictions when travelling on public transport (Fig. 54)

As accessibility in public transport is absolutely essential, the researcher asked participants if they had any physical restrictions with regards to their mobility on public transport (Fig 53) and if they encounter any sensory or communications restrictions (Fig 54). 4% of the responses indicated that they did have physical restrictions in their mobility and 10% indicated sensory or communications restrictions. This being quite a significant quantity of travellers, the researcher noted this area for further research in this study.

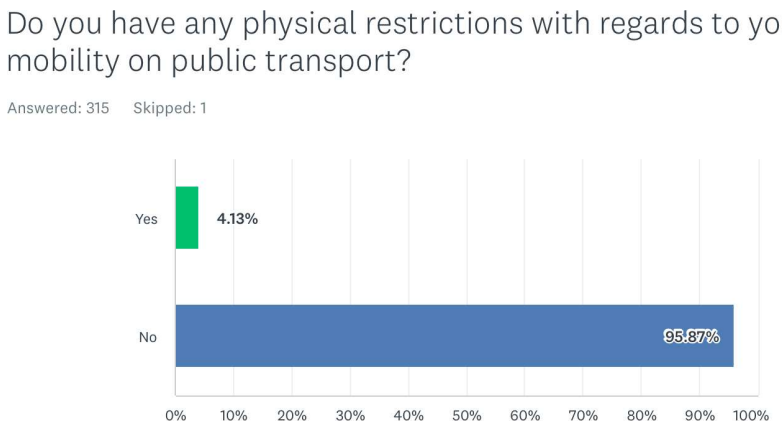


Figure 53: Users with Physical Mobility Restrictions

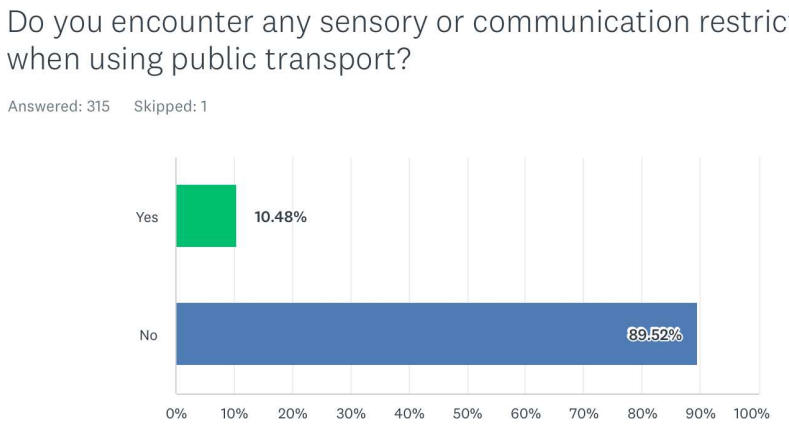


Figure 54: Users with sensory or communication restrictions

5.1.13 Additional Question for Data Quality

Data Quality - Experience of Participants - Summary Findings

- Three quarters of the participants surveyed are regular (31%) or frequent (41%) travellers and one quarter only travel occasionally (Fig 55)
- Just 2% don't use the train which would be expected as the survey was not specifically addressed to non-users (Fig 55)

To assess data quality and how relatively experienced the group of survey respondents were, the researcher asked the participants 'How often would you make trips on Irish Rail (in normal times pre covid)' in order to determine how many of the participants were frequent or occasional travellers (Fig 55). Since the survey was conducted during a time when social distancing for both leisure and commuting travel was significantly reduced the participants were asked to answer based on their past experience. Almost three quarters of the respondents were frequent or regular travellers with just 2% saying that they never travelled with the remainder being occasional travellers (Fig 55). No respondents skipped the question so the study was completed by 309 experienced travellers out of a maximum of 316 respondents. As the study is based on the 'lived experiences' of rail travellers in Ireland thereby providing a healthy and representative sample.

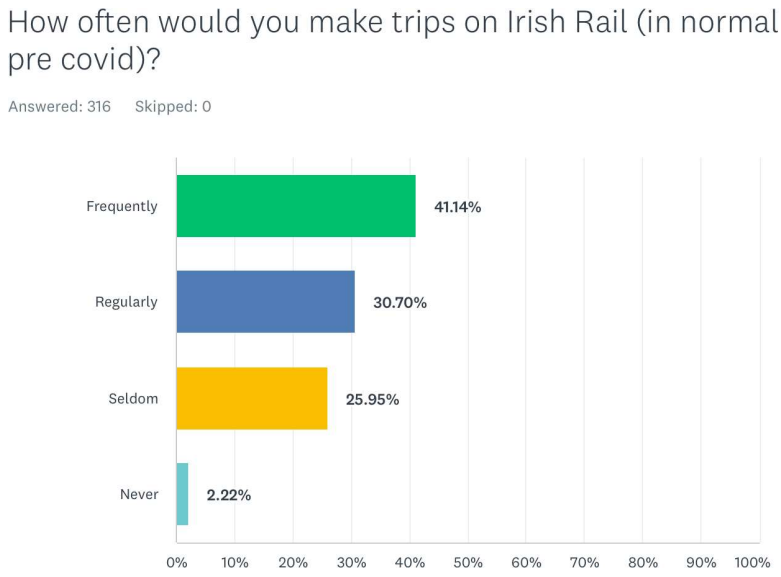


Figure 55: How often do you travel?

5.1.14 Additional Question on Customer Satisfaction

Customer Satisfaction - Summary Findings

- Satisfaction is often conditional on issues such as overcrowding, delays, anti-social behaviour or affordability (Fig 56)
- 92% of people have a generally positive experience with public transport (Fig 57)

To evaluate the level of satisfaction on the complete journey the researcher posed an open question in order to gain a deeper understanding than any quantitative type of question. This being important to understand through the online survey as in person interviews were not possible at the stations due to the pandemic. A small minority indicated they were not satisfied at all with another small group responding that they were reasonably satisfied. The largest majority indicated they were unconditionally satisfied giving a firm yes. However a large number of respondents gave a more conditional yes, indicating that they are satisfied 'if not too crowded', 'unless something goes wrong', 'unless unsocial behaviour or safer' or 'yes but wish it was cheaper' (Fig 56 & 57). Many of these responses would form the basis for further research in the study.

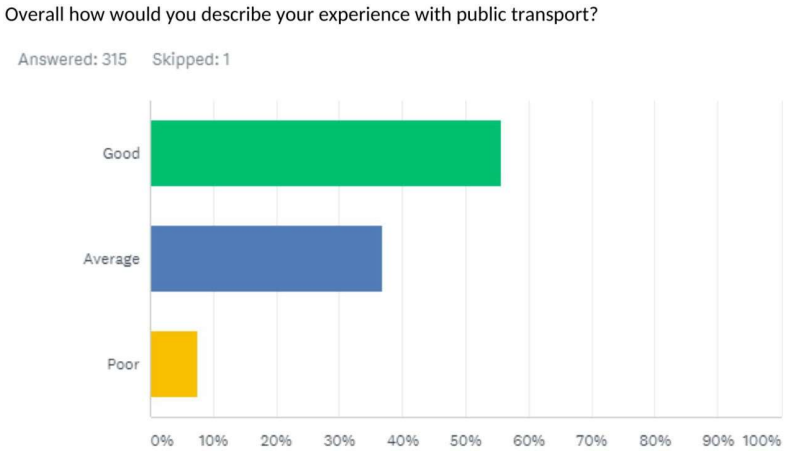


Figure 56: Customer satisfaction in general on public transport

Generally speaking, are you satisfied with your whole journey? (Open)

Yes	147
Yes, generally	29
Yes, if not too crowded	14
Yes, unless something goes wrong	17
Yes, unless there is an incident or unsocial behaviour	7
Yes, but I wish it was safer	4
Yes, but I wish it was cheaper	1
Reasonably	17
Not always	7
Not really	4
No	20

Figure 57: Satisfaction on the whole journey

5.2 Co-Design Workshops Outputs

For the purposes of simplicity the results of the four co-design workshops which included 15 participants (excluding the supervisors) are aggregated together in the following results. All outputs were subject to peer debrief for reliability and validity.

The participants adapted to the online format with ease. After some very basic instructions on using the Miro virtual whiteboard, most seemed to be quite comfortable using it. Participants were happy to have their cameras on and were willing to share their lived experiences and recount instances from their travelling relevant to the constructs under discussion. Many participants had disabilities ranging from moderate to severe and they were assisted through the co-design sessions by their fellow participants and the facilitator. All participants were very enthusiastic to participate progressing through the exercises and activities, and several followed up after the sessions with words of appreciation and praise. A small amount of people invited could not join due to a last-minute issue and sent apologies afterwards.

5.2.1 Co-Design Session – Safety

Safety Summary Findings from four Co-Design Workshops

- Waiting for the train is the stage where most travellers are afraid (Fig 58, Fig 59)
- Travellers also feel quite unsafe boarding and arriving but feel less unsafe when on-board (Fig 58, Fig 59)
- The entering and ticketing stages are seen to be 'slightly unsafe' (Fig 58, Fig 59)
- Anti-social behaviour is the main reason for fear (Fig 60, Fig 61)
- Anxiety is prevalent for many different reasons (Fig 61)

The first of the three main topics was safety and the participants were asked to move a sticky dot to each stage and these sticky dots were coloured green for safe, orange for slightly unsafe and red for unsafe. The placement of these dots from the four workshops were copied onto one board to show the aggregated result as shown below in Fig. 57 and plotted onto a graph in Fig. 58.

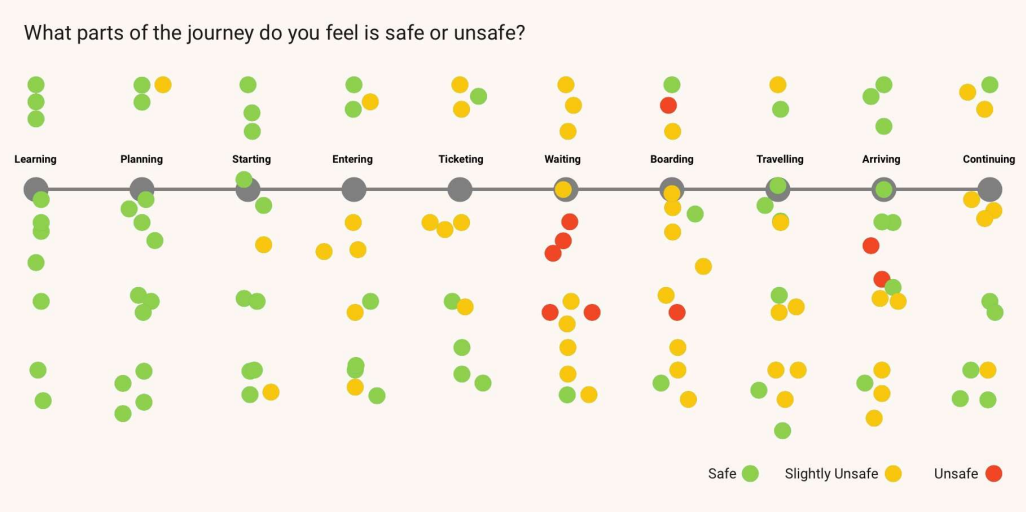


Figure 58: Screenshot from co-design workshops on personal safety

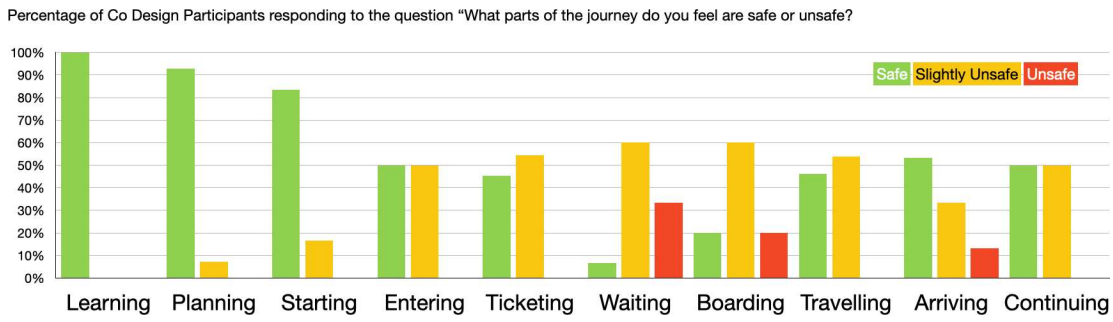


Figure 59: Responses to 'what parts of the journey feel safe or unsafe?'

Having completed this activity the co-design workshop dived deeper in all the co-design workshops beginning a conversation on 'what do you think people are afraid of?'. A sample below in Fig 59 shows some of the items one group posted.

Figure 60: Sample of some sticky notes recorded during one co-design session

The text from all of the sticky notes from all 4 workshops have been compiled into Fig 61 which shows the following themes that travellers are afraid of.

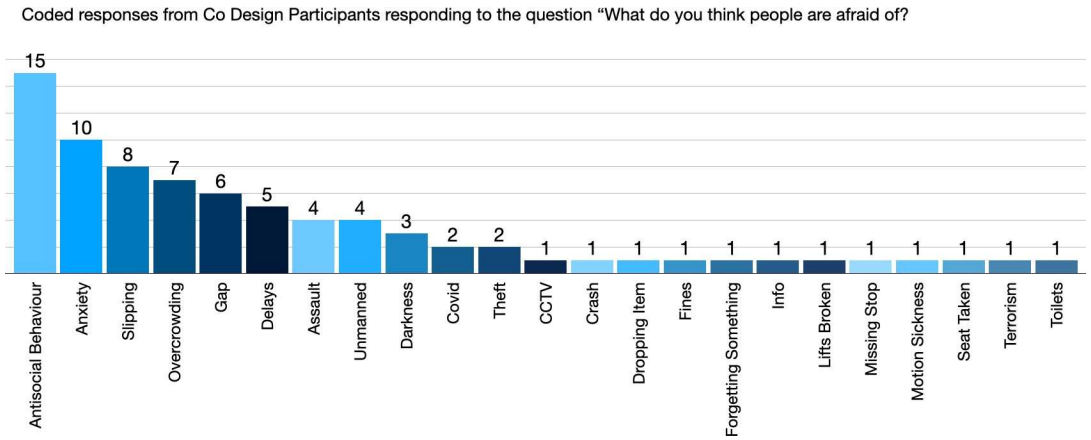


Figure 61: Responses to 'what travellers are afraid of?'

Anti-social behaviour is clearly the most mentioned item by the participants which is relatively self-explanatory some recalling incidents with intoxicated persons onboard or within stations, gangs and general nuisance. Many also mentioned some scenarios that gave rise to anxiety such as 'when my control is taken away I get anxious', 'waiting alone on a platform', 'when I am tired…I feel more uneasy' which hint at a number of factors negatively affecting the emotional state of the travellers some of which involved disabilities and bad experiences in the past.

Physical problems the stations accounted for several items such as the gap that exists between the train door and the platform which was mentioned by many participants some of whom had disabilities but many others also mentioned it. Other physical problems included slipping on platforms, CCTV and poor lighting on platforms and in car parks.

Finally several people mentioned the lack of staff around the station or actual unmanned stations as being something they were afraid of. Some of the participants took the opportunity to strongly note in conversation, that while the objective of the study related to technology improvements, they firmly believed that no technology could ever replace having staff both on-board and on-premise. During the conversations on this staffing aspect, all participants were in agreement with the person who raised it.

5.2.2 Co-Design Session – Information

Information Summary Findings from four co-design workshops

- The top requirement is for simpler info (Fig 62)
- Travellers need more accurate info on delays, platform numbers (Fig 62)
- All information needs to be accessible (Fig 62)
- Capacity information is quite important (Fig 62)
- Travellers need to know if there will be staff around or not (Fig 62)
- 'Nice to have' info includes refreshments, weather and storage info (Fig 63)

The second main theme to be discussed in the co-design workshop was 'Information' and from the preliminary survey, this theme received a considerable number of comments on the responses. These comments mentioned a wide range of items that were grouped together as being various types of information and the second activity in the co-design workshops was validated these initial findings and try to gauge which of them were the more important ones. For example knowing the weather at the destination may not be as important as knowing which platform the train departs from.

So the first part of the activity was designed for each participant to write on a sticky note in response to the question 'what are the different types of information passengers need?' (Fig 62). The second part of this activity had two areas separated by a line and the participants were asked to move their own responses to either the left or right hand side of the line (Fig 63). The left hand area was for the items they felt were 'essential' with the right hand side for 'nice to have' items.

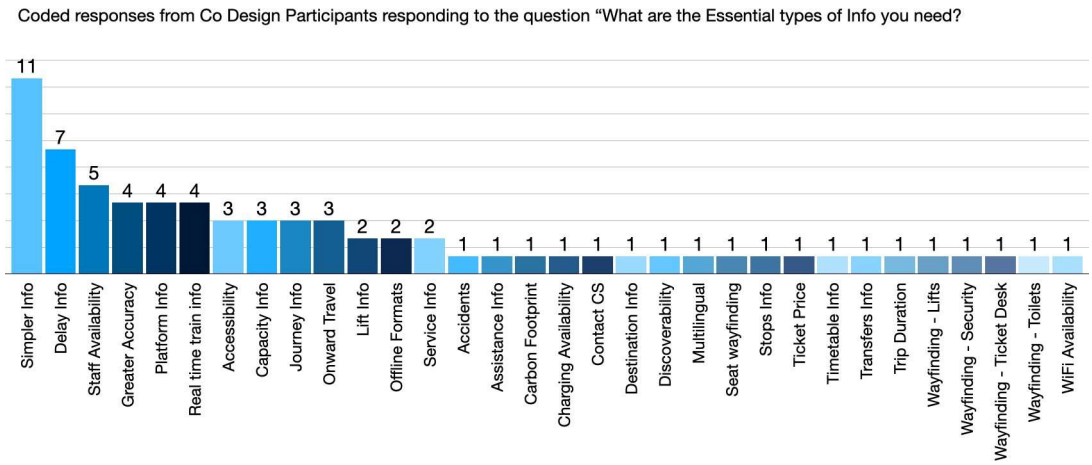


Figure 62: Responses to 'what are the essential types of info you need?'

There was a large and wide range of topics mentioned as 'Essential' to have information types. Interestingly the highest number of sticky notes recorded a desire for simpler information asking for 'easy read and understood', 'easy to access in all formats', 'keep the information simple and accessible' etc and some of the participants spoke about the current information being too complex. Participants asked for information on staff availability, which was the second highest topic mentioned. They need clear indications about where there will be staff available to help them and where there won't. Another item mentioned in the co-design workshops is the need for accuracy because sometimes what they see in reality is different to what apps or websites tell them which they find frustrating.

When delays occur, the participants noted that they were often poorly informed. They mentioned that the information is slow to be sent out and some mention having better details about what is going on and estimations how long the trains will be affected and how their connecting trains will be affected. Many participants also mentioned capacity information, 'will there be seats on the train' and some people would travel earlier or later if they knew how busy a particular train was. Participants mentioned the need for accurate platform information, they need to know in advance where they would need to be to get onto the train. They also need immediate notification if they had to be changed suddenly e.g. 'I need the platform info in time', 'any platform changes'.

Many of the participants mentioned accessibility information, both information to help people plan their trips and navigate the stations and also accessibility of the information itself. It was

mentioned that all information should be provided in different formats and languages, audio announcements should be in text format, screens on trains should have audio announcements or some means to convert the content to audio etc. The current location of the train when onboard and the next stop in accessible formats was also mentioned. In the navigation of stations, the participants talked about providing details of the layout, steps or stairs and the distance involved. As lifts and escalators are essential for some, it was mentioned that they need to have the operational status of these items in real time in case something is out of order that might make their trip impossible.

A number of other types of information were discussed such as carbon footprints, how to obtain assistance or customer service (CS), wayfinding (to seats, to facilities, to toilets, to security etc), destination and onward travel information.

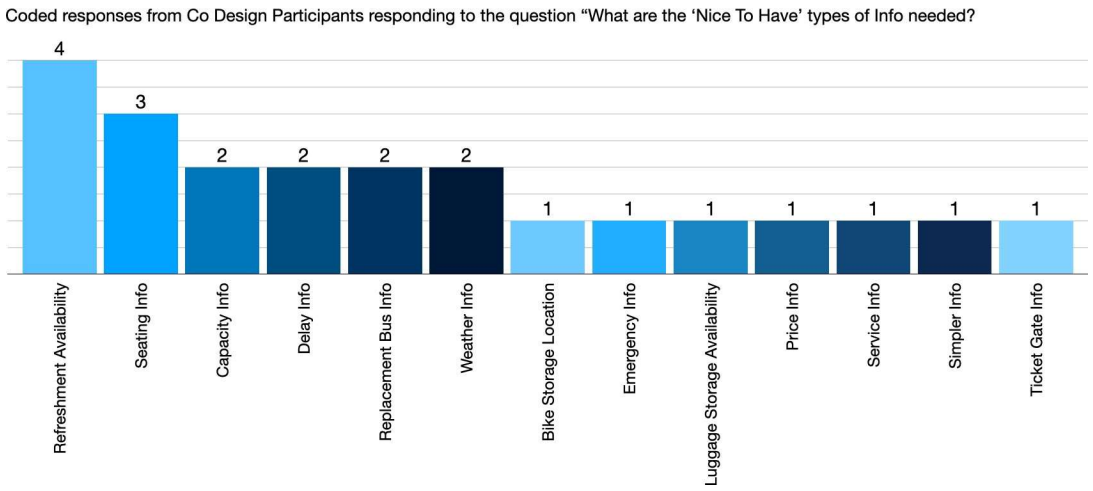


Figure 63: Responses to 'what are the nice to have types of info you need?'

5.2.3 Co-Design Session – Accessibility

Accessibility Summary Findings

- No stage of the journey is completely accessible (Fig 64)
- Travelling on board is the most accessible but problems with announcements and the next stop notification (Fig 64 and Fig 65)
- Lack of ramps and lifts out of order cause problems (Fig 63)
- Difficulties outside railway network starting and continuing show the wider problem in society (Fig 64)
- Strong need for better info for deaf and visually impaired (Fig 65 and Fig 66)
- Human assistance is crucial (Fig 66)

The third activity of the co-design workshops revolved around accessibility and while several of the participants did have sensory and cognitive problems its participants were asked to consider both themselves and others when looking into this subject. The participants were provided with sticky dots to indicate the parts of the journey they felt were accessible, slightly difficult or not accessible.

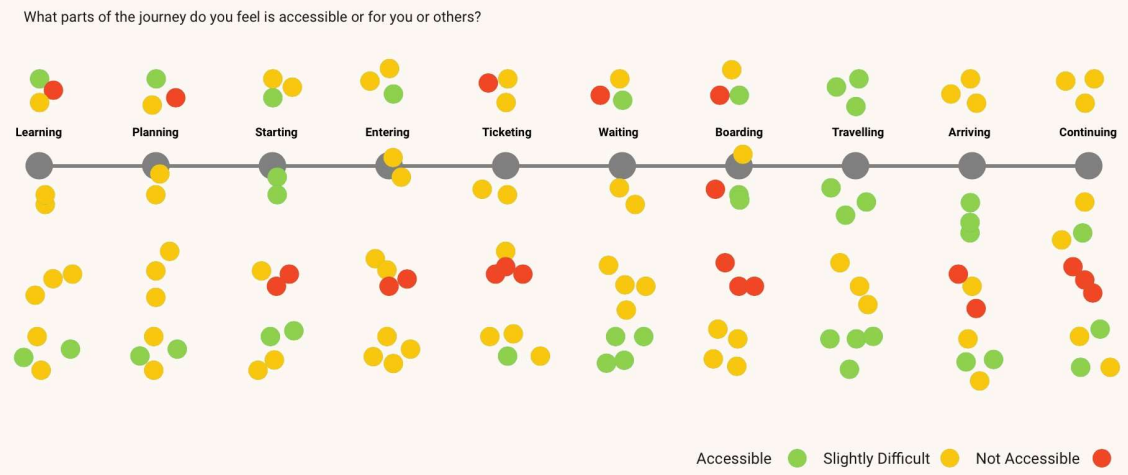


Figure 64: Screenshot from virtual whiteboard activity on accessibility

As can be seen from Fig 63, that none of the stages of the journey were considered to be fully accessible by everyone as most participants recognised the difficulties that would be faced by travellers with accessibility requirements. With the exception of riding/travelling on the train

every stage was identified as being 'not accessible' by at least one participant. The learning and planning stages were thought to be 'slightly difficult' mostly due to the perceived difficulty accessing and understanding information on train services and this was confirmed by several visually impaired participants. Starting out on the journey was considered to be quite challenging by most participants also, simply collecting personal belongings and getting to the train station was noted to be a significant challenge in itself. Due to the location of some stations and the potential for lifts and escalators to be out of service, the stage of entering was found to be quite problematic with some participants saying this stage was not accessible and only one person noted it to be fully accessible.

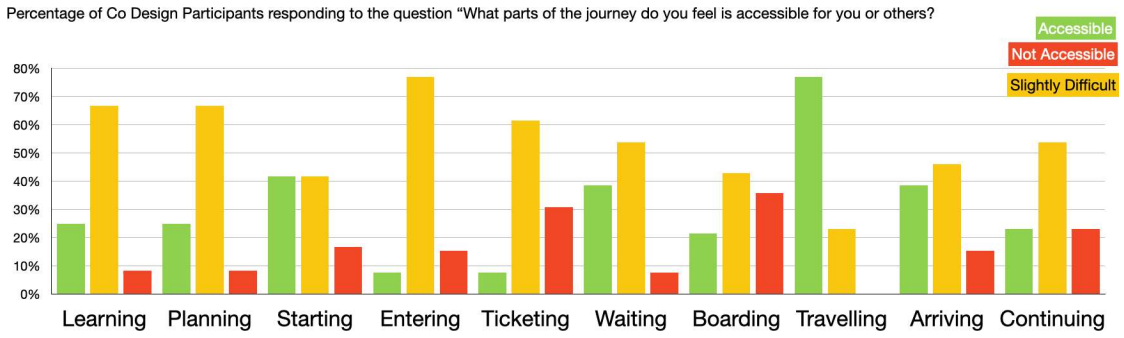


Figure 65: Accessibility across the journey

Perhaps surprisingly participants indicated they felt that the waiting stage to be mostly difficult and this was centred on the general comfort of waiting facilities in the stations and also the general difficulties either obtaining or understanding information regarding delays and sudden changes to the service. This seemed to be an issue for people with and without accessibility difficulties. Several participants mentioned that public address announcements were difficult to hear or understand and noted that the general environment in train stations can be quite noisy. Others noted that the quality of the audio can also be affected by echoes in large buildings or wind outdoors.

Boarding the train was noted in the co-design workshops to be the most challenging aspect of the entire journey in terms of accessibility. Many visually impaired people needed assistance to find the doors, overcome the gap and step and then to find a safe place to stand or sit. Wheelchair users needed assistance to overcome the gaps and height difference of the platform versus the carriage floor. It was mentioned that most wheelchair users would need a

companion to assist them or to have help arranged in advance from staff. Most participants agreed that entering the train is generally not accessible independently and some of the participants that have direct experience of this wish to be independent and able to travel and be more spontaneous i.e. without extensive pre-planning and arranging assistance.

Arriving and exiting the train seemed to be slightly less problematic and travellers were assisted regularly by other travellers and also staff who are notified at the destination. Follow on trips or continuing on to the final destination was noted to be similar in difficulty as starting out which may be a general reflection on all travel in society.

The co-design workshops then looked at 'how could the journey be easier for everyone'. This question was phrased in this way as improvements in accessibility benefit everyone and a large and wide variety of suggestions were given (Fig. 66).

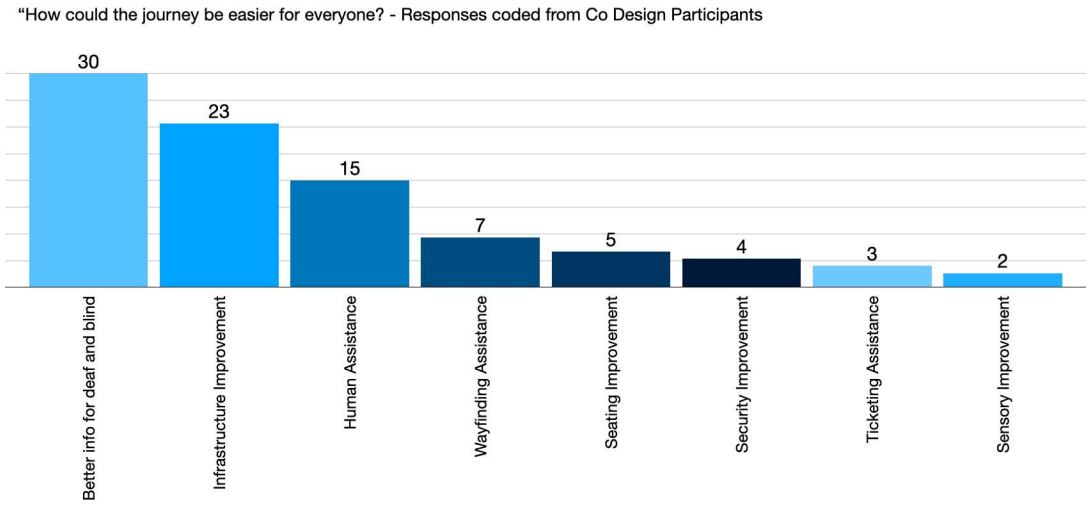


Figure 66: How could the journey be easier for everyone

Figure 66 above shows the main themes of the suggestions made. By far the largest themes involve information and access. The suggestions to improve the accessibility of information include improving the public address speakers, improving the accessibility of online and offline media such as PDF timetables, sending notifications to travellers phones when onboard especially as stops approach, providing better information online for wayfinding and improving signage on-board and in the stations.

The suggestions to improve access included removing steps and replacing with ramps, weather proofing bridges and platforms as they become slippery, improving the reliability of lifts and escalators, addressing difficulties with platform gaps, increasing the amount of tactile paving in the station environs and adding braille signage on the trains.

In this activity again the participants have made several suggestions how employees can make the journey easier for everyone. They mentioned having ‘a presence on the platform to make boarding easier’, ‘a greater level of help and support’ and ‘more customer facing staff to assist passengers’. They also mention the ability to request help if is necessary and noted that the SOS button in unmanned stations sometimes are not working. Several participants particularly those with accessibility needs mentioned improvements to wayfinding through improved signage and tactile markings on the platforms, ticket office and waiting areas.

Many of the participants took the opportunity during this activity to suggest improvements to areas which were not narrowly focused on accessibility per se but rather a cause for problems generally. These included, instances where passengers sit in seats that are pre-booked by others, which causes problems for people with invisible disabilities who book ahead because they know they will have difficulty standing for the whole journey. Others mentioned pushing at the turnstiles, finding charging points and finding the stations noisy which can all be associated with various personal issues such as agoraphobia, autism and low-battery anxiety.

5.2.4 Co-Design Session – Autonomy

Autonomy Summary Findings

- It is possible to improve autonomy by improving the door to door journey especially in the area of accessibility, safety and provision of accurate information (Fig 67)
- Employees are still an essential element for many customers
- Improved integration with other travel modes is important

The final activity of each co-design session posed the following question; 'Do you think that by making lots of improvements to Safety, Information and Accessibility on public transport, people would feel more independent and have greater autonomy?' As a key question in general for this study, can autonomy be improved.

One participant responded negatively as they felt that greater integration with other forms of transport was essential to improve autonomy. Others wished to answer both yes and no, believing in general yes the technology would help but not at the cost of human assistance, that any new technologies should complement staff not replace them because the 'human touch' was still essential to a successful trip. Everyone concurred with this viewpoint.

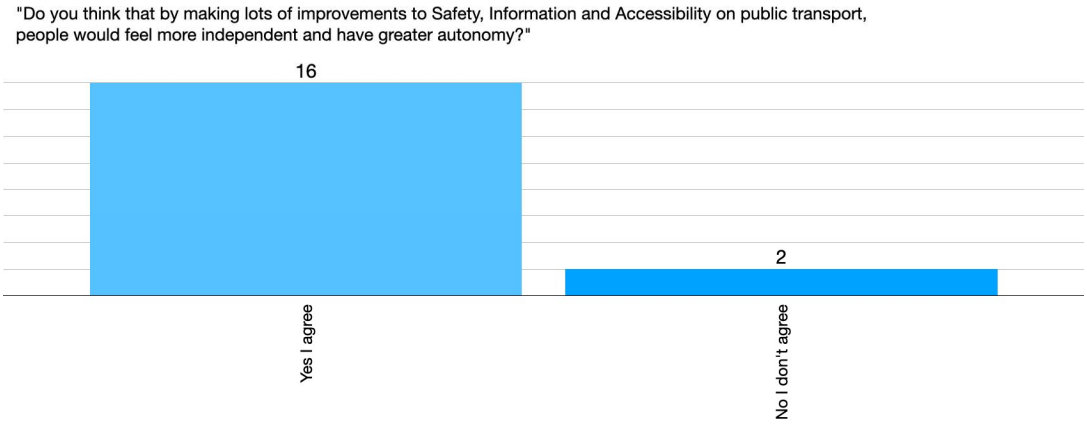


Figure 67: Can improvements increase autonomy?

5.3 Key Improvements vis-a-vis Stakeholders

Users' needs identified during the study are graded against the primary stakeholders involved and assessed in the context of a potential information technology solution.

Table 19: Users needs with potential interactive system solution

Description of User Need	Main Stakeholders	Potential IT Solution
Network and Destination Guides	Irish Rail	Yes
Reporting Anti-social Behaviour and Calling for Help	Irish Rail / Gardai (Irish Police)	Yes
Better Integration with other travel modes	Irish Rail / National Transport Authority	Partially
Carbon Calculator	Irish Rail	Yes
Communicating Delays in real time and accurately	Irish Rail	Yes
Easier Exiting at end of journey	Irish Rail	Partially
Comparison of Travel Modes	Irish Rail	Yes
Providing Real Time Platform info including notifications if sudden changes	Irish Rail	Yes
Info on Facilities Available	Irish Rail	Yes
Quiet Areas in trains and stations	Irish Rail	Partially
Way-finding inside train to Seat Reserved to Bike / Wheelchair Space	Irish Rail	Partially
Way-finding Out of Station and Onward	Irish Rail	Yes
Detailed Accessibility Info	Irish Rail	Yes
Way-finding To Station and Inside it	Irish Rail	Partially
Cheaper fares and mobile ticketing.	Irish Rail / National Transport Authority	Partially
Improved reliability	Irish Rail	No
Comparing Trains Quick vs Quiet etc	Irish Rail	Yes
Highly Accurate: Train Position / Delay / Next Stop / Lift Status / Capacity	Irish Rail	Yes
Capacity Prediction	Irish Rail	Yes
More and Improved Ticket Vending Machines	Irish Rail	Partially
Improved Capacity for People Bikes and Propriety Passengers	Irish Rail / National Transport Authority	No
Improved Facilities In Station	Irish Rail	No
More car and bike parking spaces.	CIE Property / Local Authorities	No
Info on Refreshments and Ordering	Irish Rail	Yes
Human Assistance	Irish Rail	Partially
WIFI and Charging	Irish Rail	No

Stations and trains to be designed better so they are more accessible and easier to use, brighter, more comfortable and weather protected.	Irish Rail	No
Safer environment with means to request help / assistance and more CCTV.	Irish Rail	Partially
Ability to report faults such as lifts out of order etc and also to report dirty areas and suggest improvements	Irish Rail	Yes
Simpler and Accessible Information, better Signage and Way-finding.	Irish Rail	Yes
Larger railway network, more trains, multi modal.	Irish Rail / National Transport Authority	Partially

5.4 Synthesis

As a quantity of both quantitative and qualitative data is collected in this study, the process of synthesising and analysing this data is important to carefully reduce data into key insights that inform the research questions. These key insights are visualised for a high-level view of the complex findings as documented in the previous chapter. Patterns, relationships, categories and codes from the qualitative data and analysis were collated and triangulated with the most important statistics from the quantitative research into visual form. This collation followed an iterative process using a research wall and a process of sketching to generate means to visualise outcomes. Peer review from the supervisory team was essential in this synthesis stage, and feedback assisted in validating the visualisations to present the key insights.

As the research question addresses the door-to-door customer journey for Irish Rail, an experience map (section 5.5 and appendix A) was developed, showing the ten stages of the customer journey. This map describes each stage and includes a sample of one of the primary thoughts or insights detailed in 5.1 and 5.2. Graphs Fig 59 and Fig 66 have been simplified to show the parts of the journey that cause concerns to travellers. Gaps for information needs raised during the surveys and co-design workshop are then noted. Finally, the main opportunities for Irish Rail to improve the customer experience journey are summarised from reviewing the survey results, notes, and comments from the co-design workshop and from re-reading all relevant individual comments throughout the study that triangulated with the research question.

A visualised thematic analysis has also been generated, merging the emergent themes from the survey and co-design sessions, capturing close to 5000 comments (section 5.6 and appendix A). These themes are mapped to the customer journey stages to visualise how Irish Rail and the other stakeholders can support the traveller at every stage. This thematic analysis shows how

some potential improvements in the whole public transport sector can assist the traveller across many different stages, while others may focus on a single stage.

Finally, a conceptual design is produced based on the needs and gaps of the traveller in a visual format to communicate the underlying ideas behind improving the door-to-door customer journey at the centre of the research (section 5.7 and appendix A). In this conceptual design, a process of iterative design is applied to visualise an ‘ideal’ scenario. The travellers' needs have been grouped and categorised, and key areas to support the traveller are proposed, e.g., Discovery, Planning, Ticketing and Travel Assistant taking the first steps towards finding a solution to the traveller’s needs.

5.5 Door-to-Door Experience Map

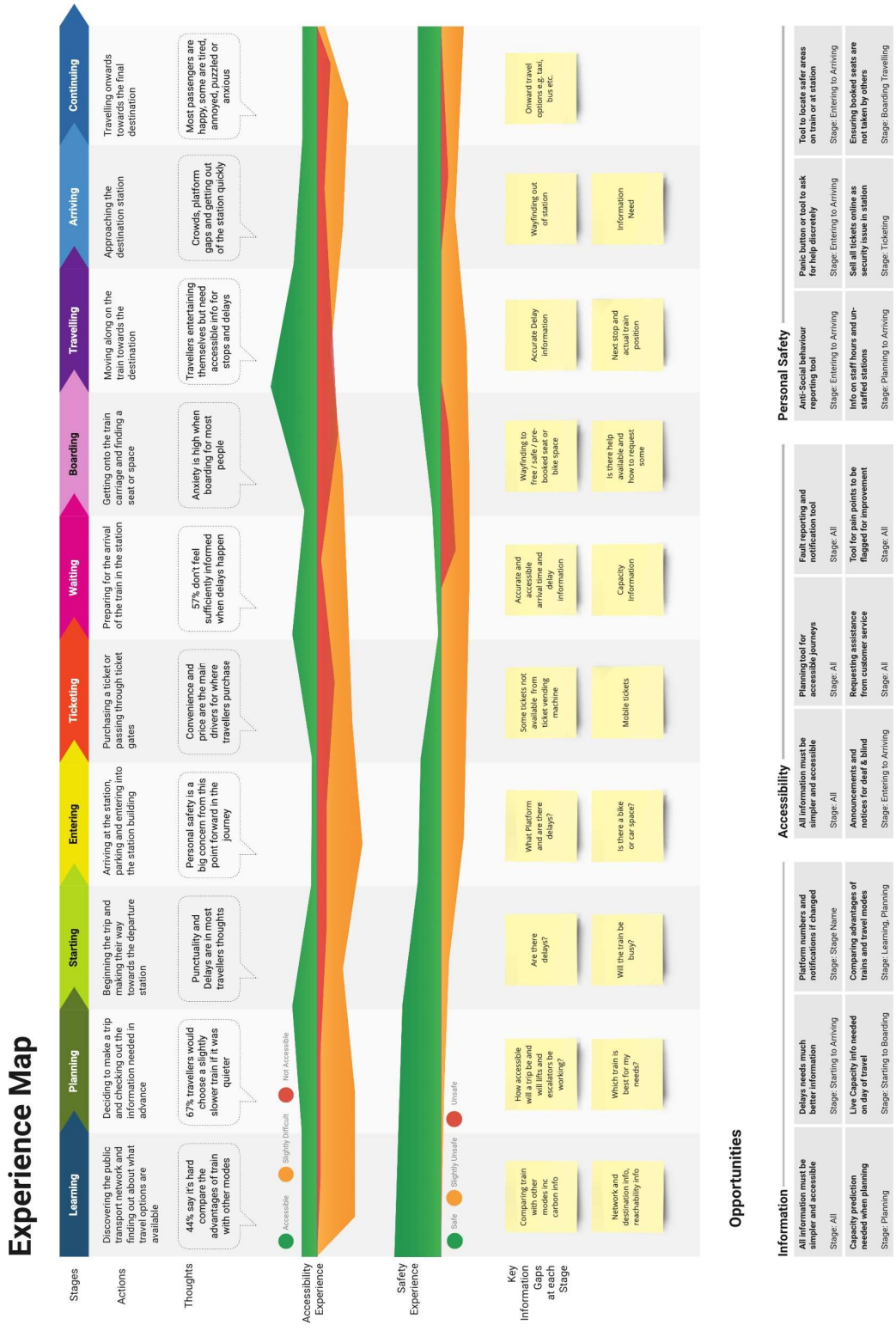


Figure 68: Experience Map for Irish Rail (High Resolution version in Appendix A)

5.6 Visualised Thematic Analysis

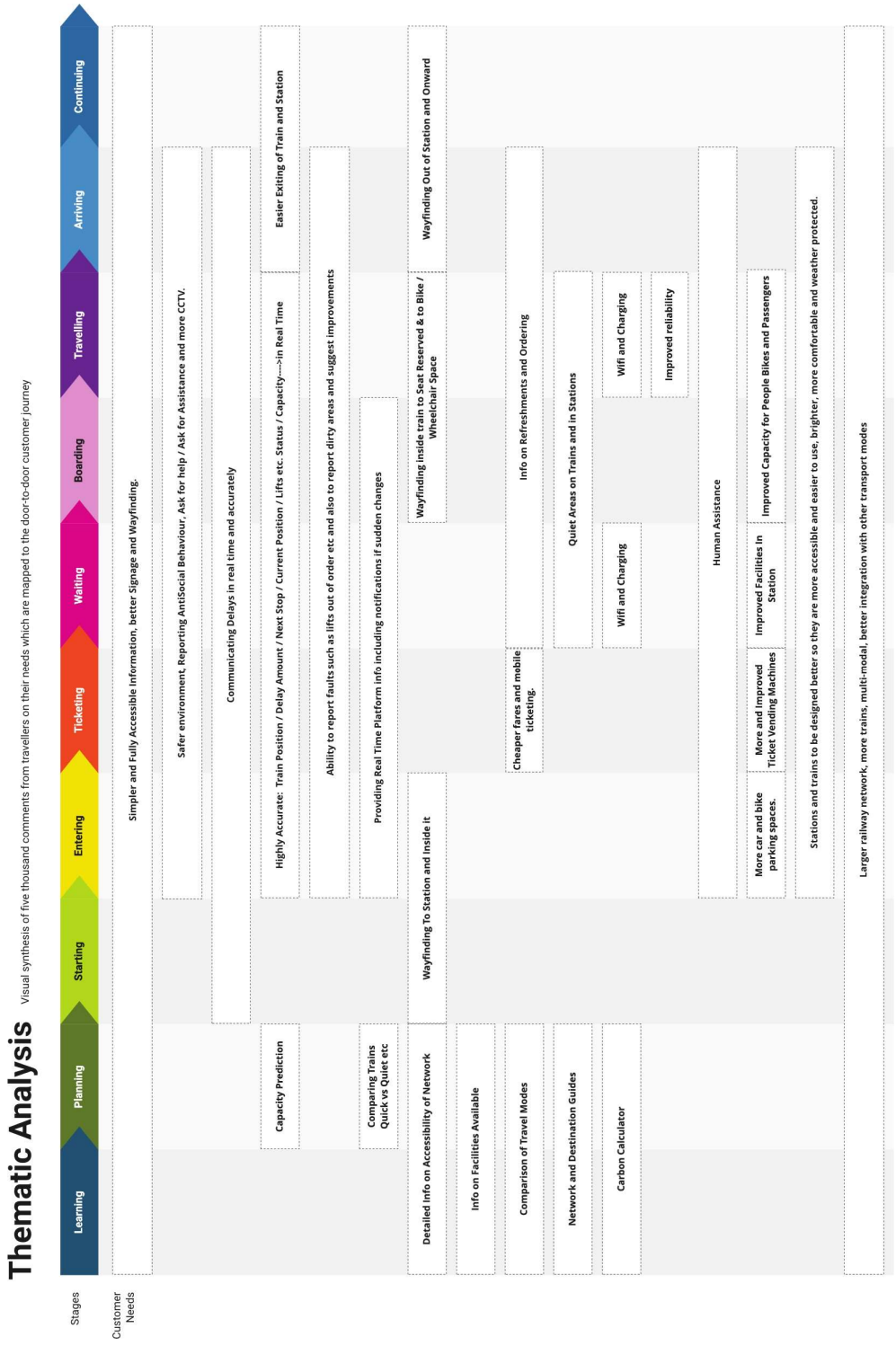


Figure 69: Visualised Thematic Analysis (High Resolution version in Appendix A)

5.7 Conceptual Design

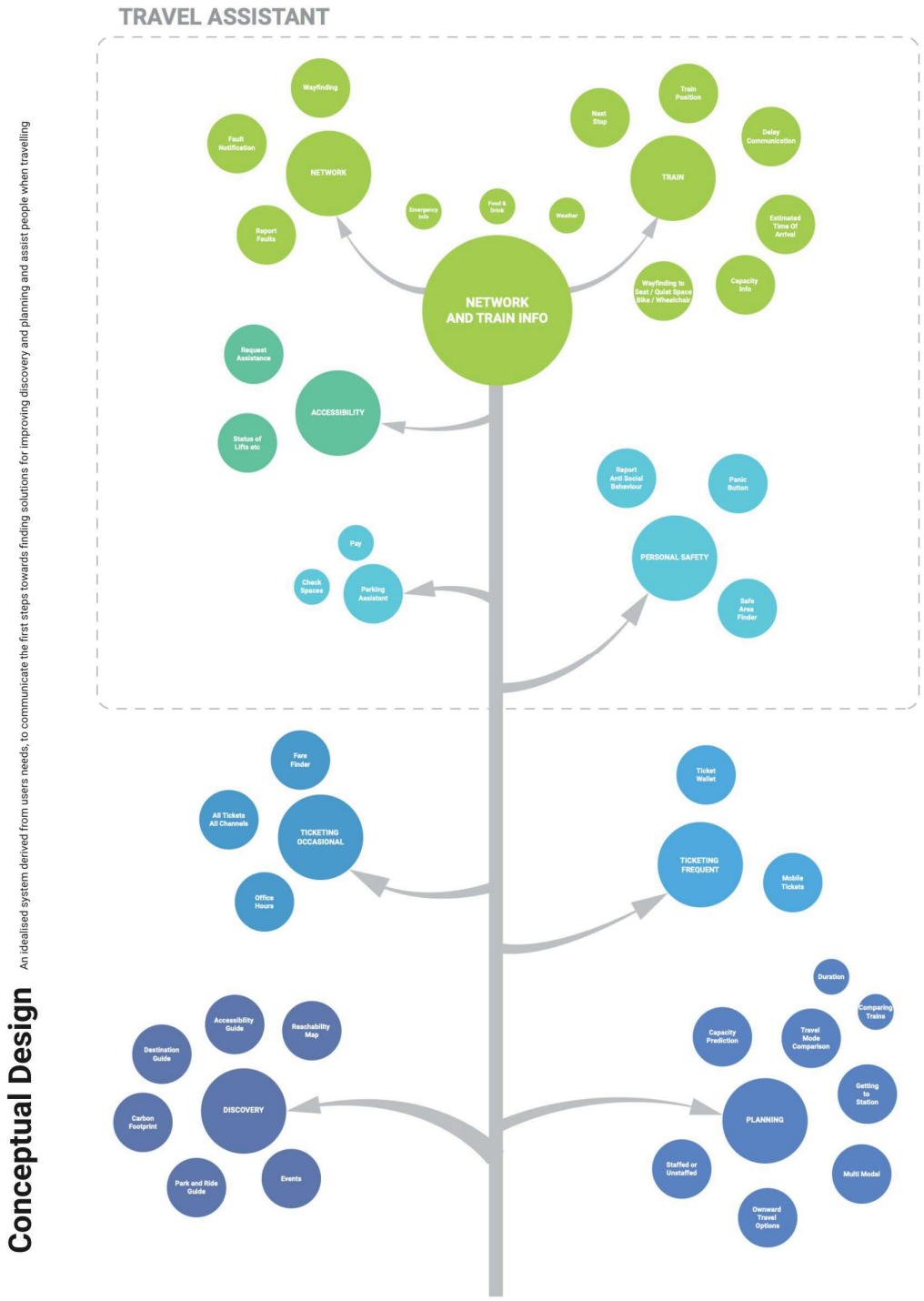


Figure 70: Conceptual Design (High Resolution version in Appendix A)

5.8 Design Book for Irish Rail

Irish Rail does not have a culture of design and this research shows the value that designing for the user can bring to the company. The production of the following design book will begin a process of design advocacy by the researcher in the organisation. The first version of this book is created for PowerPoint to use at meetings and workshops in Irish Rail. Further audio visual presentations for internal networks and will be will be generated. After consultation with Irish Rail, this guide will be used in the workflow of the procurement for all IT projects and the continuous service improvement of existing systems. Photographs reproduced with permission (Travis, D., 2020)

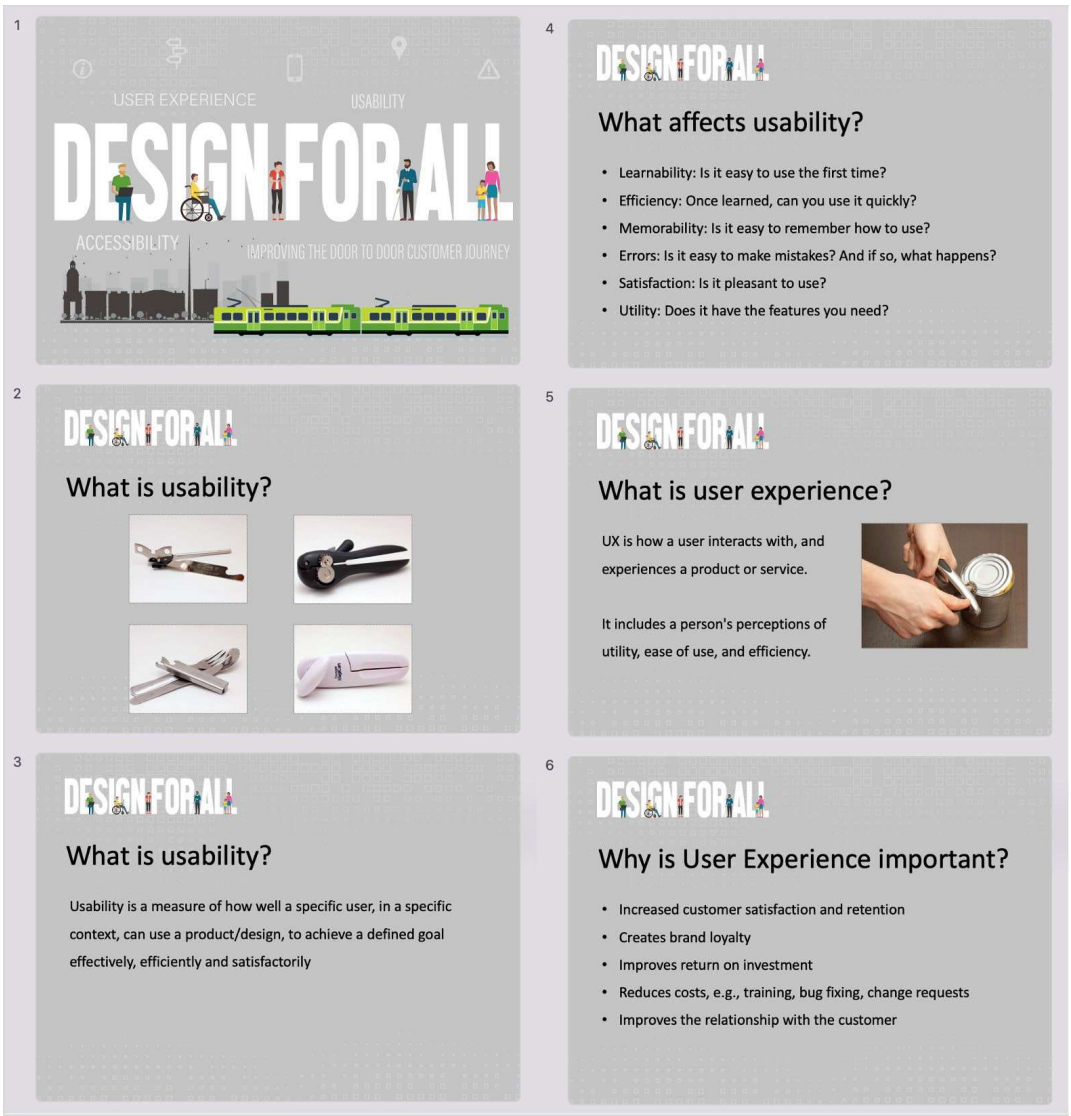


Figure 71: Design Book for Irish Rail (High Resolution version in Appendix C)

Figure 72: Design Book for Irish Rail (High Resolution version in Appendix C)

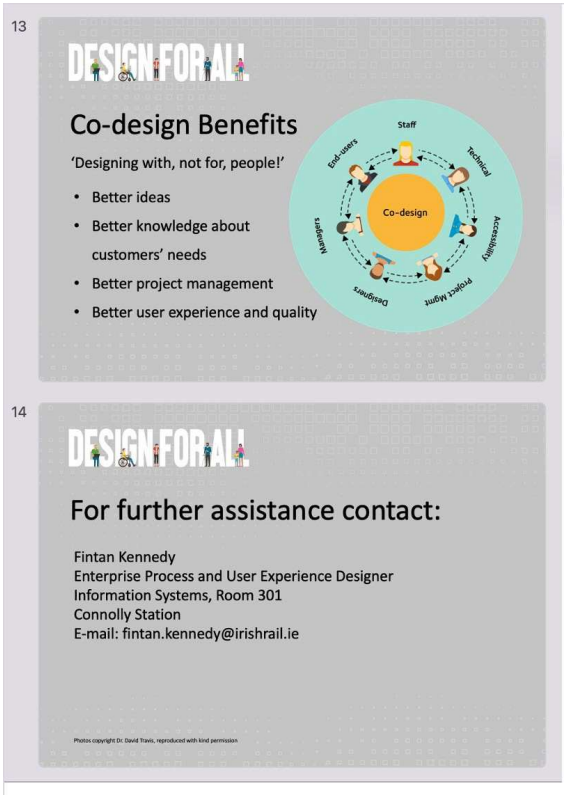


Figure 73: Design Book for Irish Rail (High Resolution version in Appendix C)

5.9 Literature review conclusions vs research findings

- Door-to-door journey must be considered when looking for improvements

  It is clear from the results that users do have many needs before and after the journey itself, the research findings support this literature review conclusion.
- Different users have specific needs across this journey

  Results show a variety of needs which vary from person to person which was especially evident during the co-design sessions which corresponds with the literature review
- Problems can arise when these needs are unmet

  Uncertainty, anxiety and frustration is evident from both the surveys and co-design workshops, when travellers do not have the assistance they require does indeed cause problems.
- Improvements; can have a significant impact on users

Co-design participants say improvements will increase their autonomy and everyone that participated did agree that improvements will be helpful.

- Improvements; doing nothing could be against the law

  There were no specific activities within the research soliciting any regulatory or legal opinion, therefore this conclusion from the literature review could not be upheld via the results.

- Co-designing with users will uncover some improvements that are needed

  The preliminary research provided an excellent starting point for the co-designing activities which was successful in uncovering improvement areas, thus supporting the literature review conclusion.

- Suggested improvements can be cross-referenced against Irish Rail's remit

  All the research activities uncovered a large amount of suggestions, but Irish Rail would not be responsible for all these areas that users need improvements.

- Irish Rail can implement co-designing in further research

  The co-designing activities were all very positive and relatively straightforward to co-ordinate, operate and derive conclusions. The company can and should implement further co-designing.

- Design system in the form of a guide or policy for Irish Rail should be introduced (as presently does not exist)

  As can be seen from the literature review the UK’s Network Rail have such a design system published and would be recommended for Irish Rail to do also.

5.10 Future Research

Survey recruitment was carried out online, and it is most likely that the participants were computer literate. Future research aimed at travellers that are less likely to use technology should be undertaken to ensure their needs are also considered.

Directly contacting all the main public transport companies may also yield additional info not publicly available which could be considered for further research.

This research was designed for existing travellers whom Irish Rail needs to retain; however, there is a need to research any potential technologies that could encourage Irelands car owners to switch some of their journeys to the train.

While interactive systems and technology are the main focus of this study, and while some of the customers' needs fell outside this area, a separate study on improving the rail network, in general, would be very useful also.

The Design Book in Section 5.8 and Appendix C is only a starting point for evangelising design research in Irish Rail. Additional research will be essential to develop further this book and other resources for Irish Rail projects.

Finally, many participants noted a preference for human assistance from staff during this research. These employees are vital for the customer experience, and design research should be carried out to ensure that they have all the tools they need to support the customer.

Chapter 6: Thesis Conclusion

This research aimed to investigate if it was possible to improve the door-to-door customer journey experience for public transport travellers, particularly the customers of Irish Rail, through the introduction of new or improved technologies. Additionally, the research sought to answer, whether some proposed technologies could improve the sense of freedom or autonomy? A literature review only partially revealed the effects of implementing new technologies as these technologies appeared to be somewhat narrowly focused on revenue generation and train timekeeping. However through this design research and co-design, the study has uncovered a deep understanding of Irish Rail travellers' mindset and lived experiences and supports the hypothesis; It is not only possible to improve the door to door experience, it may be possible to completely transform this experience in a positive way.

The research took the holistic viewpoint of the entire customer journey and observed a very high level of generally positive customer satisfaction. However there are many gaps that Irish Rail and public transport companies need to fill in order to improve the experience for everyone;

- Personal safety is a major issue which has affected the majority of travellers
- The network needs to be accessible and information provided on this accessibility
- All information needs to be simpler and fully accessible
- Travellers need much more information and it must be very accurate

Potential improvements based on all the data reviewed during this study are cross referenced with the diverse stakeholders within the industry and finds that there are a considerable number of ways to support the passenger throughout the door-to-door customer journey through the provision of information technology and interactive systems. By focusing on the areas of accessibility, personal safety and improved information, Irish Rail aid travellers decision-making and reducing stress and uncertainty.

The co-design approach adopted in this study demonstrates the capability to gain a deep understanding of the problems that passengers face and how a 'design for all' mindset can improve the complete customer journey. This approach is not currently used in Irish Rail;

however, the design methods used throughout the study will be provided to them along with the following;

Assets from this Study for Irish Rail include:

- Lists of potential interactive systems focused on the needs of travellers
- Experience Map summarising the main conclusions from this study
- Visualised Thematic Analysis and Conceptual Design
- Design for All guide to aid projects and future research

To conclude, there are many ways in which Irish Rail can use technology to improve travellers door-to-door experience. By drawing on the travellers' lived experience through co-designing with them, Irish Rail can simplify and transform the door-to-door customer journey and introduce changes that will benefit everyone. To be successful in this Irish Rail will need to adopt design and designing and the knowledge and assets gained via this study will be starting point in a new journey of design.

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