EINDHOVEN UNIVERSITY OF TECHNOLOGY

0HM110 – USER EXPERIENCE DESIGN

FINAL REPORT

GROUP 4

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I. Abstract

The Technical University of Eindhoven's campus is large and has a complex layout, resulting in students having navigational issues when trying to find their way to a new building. This paper attempts to understand not only the background information on the topic, but also the specific problems individuals experience and how they affect the individual. This was done using literature research and interviewing people who attend the TU/e campus. Results from the user research showed that cognitive mapping and landmark usage were key factors in navigating the campus, whilst the affective (emotional) state of individuals was greatly affected when they lost their way.

From the user research, a concept was developed that would facilitate the usage of buildings as landmarks and, in turn, improve the cognitive mapping process individuals undergo when navigating a new location. Additionally, the system makes itself obsolete as an individual's cognitive map becomes more developed, allowing for independent navigation in the future. The concept, an embedded navigation system that relies on symbols (placed on the side of buildings) to help users find their way on campus, was designed to be technologically-independent so that it could be used by everyone, whilst an interactive-screen prototype was developed that could help users locate where they must go and teach them how to follow the embedded system. The concept and prototype were then evaluated with users to determine the design's level of accessibility and applicability, along with discovering aspects of the design that we had not yet considered. The project was then assessed and reflected upon, with the encountered limitations described, as well as the possible future work that can be undertaken.

1. Introduction

At the time of writing, Eindhoven University of Technology is working hard to realise their 'Campus 2020' plan (Campus 2020, 2016). The plan is to create a compact campus, where the boundaries between industry and science fade through flexible utilisation of buildings, rooms, and laboratories, creating "a vibrant area, bristling with activities, that's a nice place to be even after five [pm]". Efficient use and sharing of the facilities implies surplus buildings can be disposed of. However, it also means that the growing number of working and studying individuals need to be able to find their way around the enormous variety of facilities the campus offers. Navigating through the 750,000m^2 campus, with a staggering 39 buildings, can be a challenging task. With no proper addresses, multiple entrances for each building, and the minimal – often confusing – signage, matters become more complicated. The navigational aids offered within buildings are no better, and are often inconsistent between buildings, in both implementation and style.

This paper describes our investigation into the navigational issues faced by campus users, being aimed at better understanding the problems faced whilst navigating and, based on a proper understanding of the problems and user-needs, proposing new and creative ideas which contribute to a solution to these problems.

During the project, we made use of the principles associated with Human Centred Design (the value of which is illustrated by Bannon, 2011) and incorporated techniques from several aspects of the co-creation and participatory design approaches (see Sanders & Stappers, 2007, for a review). For example, this can be observed in the use of a creative scenario task in the initial interview stage, as well as in the iterations of the development cycle, in which designs are made, evaluated with users, and improved.

Semi-structured interviews were conducted to help identify if problems occur and what kind of problems visitors might experience when trying to locate and navigate their way on the TU/e campus and within buildings. Furthermore, special attention was paid to the consequences these issues had, both in terms of practical and emotional effects.

The initial section of the interviews consisted of open-ended questions, aimed at exploring the interviewee's goals whilst on campus, the different methods of way-finding and navigation used, and the possible problems they encountered whilst doing so. Furthermore, the open-ended questions explored the impact of these problems. The second section of the interview consisted of a creative and playful, scenario-based method of inquiry, in which interviewees were presented with several different pairs of start- and end-points, and were asked to describe how they would navigate from start to end. They were instructed to describe the route taken, as well as any thoughts, sights, or tools used in the process. The insights gathered from the scenario-section of the interviews was an extremely valuable tool for the development of a solution to the encountered problems.

From the data obtained, we were able to identify two distinct groups based on their ability to navigate the campus, which were subsequently used to construct two personas which we believed would represent an ideal member of each group. The first group claimed to "just know" their way around the campus without encountering any major problems, consisting of students who had attended the campus for several years. The second group encountered major problems, whilst the abundance of tools available did not make any significant (long-term) difference. This group consisted of students who had only been active on campus for a short time.

Careful analysis of the gathered data revealed that the emotional effects of not being able to find a location, or of being completely lost, were quite severe. Participants were seen to experience a range

of emotions and feelings, such as severe stress, annoyance, and even anger. Moreover, being lost also affected how (mainly) students regarded themselves in a social context, as not being able to find their way resulted in being late for meeting and lectures, causing embarrassment in the user. This resulted from not only the student being late, but also from having to admit to their peers that they did not know the way.

The problems encountered tended to be caused by a general lack of (intimate) familiarity with the campus and its layout. The inexperienced users were familiar with only a few of the main buildings, and those associated with their faculty, being heavily reliant on just a handful of memorised routes they learned during the introduction week. Unfortunately, they were unable to integrate their knowledge of the campus into a holistic view of it, making navigation and travelling not only difficult, but also very inefficient.

Careful analysis of the interviews conducted with experience students showed that they possess a cognitive map; a mental map of the campus layout. Consistent with cognitive mapping theories (as described by Eilam, 2014; and Jacobs & Schenk, 2003), landmarks play a key-role in the way students navigate the campus. This cognitive map and the clever (and often unconscious) use of landmarks allowed them to easily and effectively navigate almost anywhere on campus.

This led to the idea that, if we are able to facilitate the construction of a cognitive map, students would be able to navigate independently in the long-term, without the use of complicated tools. This established the challenge of designing a system that could directly help students find their way in the short-term, whilst also making itself superfluous in the long-term. Furthermore, we agreed that any external (technologically-based) tools that would form part of the solution should be ambient, that is, integrated within the environment, rather than being an object or piece of software that users would have to carry with them.

The next section (chapter 2) provides a bit of background information regarding navigation and way-finding tools. It specifically touches upon the topic of maps, and the important role landmarks play in (human) navigation. The third chapter discusses, in detail, the method used to perform a qualitative assessment of the user's needs for the study. It also provides motivation for our choice regarding the use of semi-structured interviews as a method of inquiry as compared with other tools on offer in the user-researcher's toolbox.

Chapter 4 presents the insights obtained during the user-needs study. The first section details the three themes that were identified as playing a key-roles in navigation on campus, along with the problems that can arise from each. The second section comprises a persona derived from first-year interviewees, designed to denote a prototypical first-year student, representing the goals, needs, and problems associated with our target group. The fifth chapter then outlines how our persona should benefit from the designed solution through the use of two distinct scenarios. It also contains the first look at the core elements of our solution.

In chapter 6 we provide a detailed account of how our design concept came to be, along with supporting arguments regarding its expected effectiveness. Also included in this chapter is a full description of our prototype, along with useful images. Chapter 7 presents the method and results of the user testing stage, designed to evaluate the effectiveness of the prototype. Lastly, chapter 8 provides a critical discussion of the research and design processes and their limitations, along with suggestions for future research.

2. Background

Advancement in technology combined with low price has resulted in the development of new navigation tools. Finding one's way around complex and unfamiliar settings like airports, hospitals or universities can be tedious and frustrating, and it is necessary to identify the strategies employed by people to navigate in such an environment (Karimi, Dias, Pearlman & Zimmerman, 2014). Rather than coming up with a new tool for navigation, we aim to enhance the strategies used by people for navigation while they are on TU/e campus.

2.1. The Role of Maps

Maps in various forms have been in use for centuries to support mobility. Of the different forms of maps available, you-are-here maps (Levine, 1982) and dynamic navigation tools that depend on GPS (Willis, Hölscher, Wilbertz & Li, 2009), are commonly used for wayfinding.

'You-are-here' wall-mounted maps are found almost everywhere on TU/e campus. Although they are widely used, a study conducted by Butler, Acquino, Hissong & Scott (1993) found that a lot of time is wasted on reading the map and hence subsequently delaying the navigation process. These drawbacks of wall-mounted maps have made people depend on digital maps for navigation.

Mobile phone application uses GPS technology for aiding navigation. Although this system will provide accurate navigational directions outside a building, it fails when used inside a building. This is because a variety of physical barriers make it difficult to identify the exact location of the user.

2.2. The Role of Landmarks

"Landmarks are stationary, distinct, salient objects or places, which serve as cues for structuring and building a mental representation of the surrounding area" (Millonig & Schechtner, 2007, p. 44). In landmark-based navigation people choose an identifiable feature like buildings or special architectural designs in the environment as a base and explore the area from the base (Makri, Zlatanova, & Verbree, 2015). While navigating through a large area, more than one landmark is used, and these landmarks help in the construction of the cognitive map of the environment (Jacobs & Schenk, 2003). Further, a study conducted by May, Ross, Bayer & Tarkiainen (2003) found that landmarks simplified the task of navigation.

Although people use you-are-here and digital maps for navigation, an increased familiarity with the environment enables people to use their cognitive maps for navigation in the environment (Willis, Hölscher, Wilbertz & Li, 2009).

To fully understand how someone navigates the TU/e campus and their mindset while doing so, and in turn develop viable solutions for the issues they may encounter, a series of research questions were developed. The following list presents the three main questions we wished to answer during the study:

- What are the main problems associated with navigating the TU/e campus?
- How do these problems affect the individual, with regards to their cognitive perception and emotional attitude?
- Is it possible to limit these issues and, if so, what is the most proficient method?

3. User Research – Needs

The aim of this study not only includes finding out where navigational issues arise and what the existing problems are, but also understanding the emotional effect on a person when they lose their way. A qualitative study was conducted to determine the aims mentioned, in which we selected semi-structured interviews due to their suitability for situations where multiple interviewers are conducting the research and where the interviewee can only be interviewed once. Additionally, the time constraint was a major factor leading to this interview style.

In the interview, participants were asked whether they had ever encountered problems and how they handled it, focusing on the effects these issues had on their moods. Additionally, the participants were asked to describe a scenario in which they had to navigate from one room in a certain building to a one in a different building. The following section further describes the method used for our research.

3.1. Method

3.1.1. Participants

In order to get a varied perspective on the navigational problems faced, each author was asked to interview 3 participants (6 authors, 18 participants in total) that were recruited from the staff and students attending TU Eindhoven. Ages ranged from 17 to 65, with both males and females being interviewed, along with participants from various nationalities. All the participants were selected via personal contact with the authors.

3.1.2. Procedure

The interview comprised of two sections, which combined took between 15 and 30 minutes to complete. Initially, the participant's demographic, such as their age, gender, and profession, was determined. The interview proceeded with questions regarding the participant's reasons for, and frequency of, visiting the TU/e campus. The final questions of the first section focused on the participant's familiarity with the campus' layout and buildings, and on problems they may have encountered whilst navigating the campus.

From a total of 27 questions initially devised for the interview, within the categories 'Personal', 'Getting lost', 'Problems encountered' and 'Navigation technique'; 10 questions were retained in the final interview guide. The original 27 questions were composed during both a brainstorming session and through individual work by the authors, with the final selection being made by the authors. The detailed interview guide can be found in Appendix A.

The second section of the interview was far more open, being conducted in the form of scenario solving. Each scenario comprised of a start- and an end-point, with each point being a specific room in a particular building on the TU/e campus.

Participants were then asked how they would navigate each of the scenarios. Although this is not as ideal an exercise as navigating on the actual campus itself, this method of inquiry is meant to observe how participants go about finding their way through the campus and to observe the obstacles they face whilst doing so. Please note that whether participants are able to describe the 'correct route', and for how many of the scenario's they are able to do this, is not necessarily of interest. They are merely tools to provoke thinking aloud.

A total of 5 scenarios were devised by the authors. In these, both buildings with a high probability of familiarity and buildings with a low probability of familiarity are represented. The distance between the start- and end-points also varied considerably between scenarios. For example, one of the scenarios comprised of two points located at opposite sides of the campus, whilst another consisted of two points in buildings adjacent to one another. This range of scenarios were sufficient in offering each of the participants at least one route they are familiar with, and at least one in which they are only partially familiar with.

3.1.3. Material

In addition to the building names and room numbers of the start- and end-points provided during the navigational portion of the interview, the participants were also provided with a map of the TU/e campus (from which the building names have been removed). This provided the interviewee with certain reference points that are only known visually (such as roundabouts, etc.).

3.1.4. Data Collection & Analysis

Most of the interviews were accompanied by an audio recording, which was transcribed by the respective authors. One of the main focuses during data collection was observing how the participants answered the questions. This focus followed their choice of words, intonation, repetition of words, and the extent to which questions were answered/not answered. In particular, we wished to determine the behaviour and affective state of each participant whilst navigating, from which specific themes could be derived and initial insights on the data could be gathered.

Each transcript was read multiple times in order to facilitate familiarisation with the data set. From the transcripts, codes were generated manually by noting key phrases on Post-It notes and then grouping them within related themes. The content of each theme was reviewed, resulting in appropriate titles for each major theme. A thematic map was created to help visualise and explore the relationships between the themes. The thematic map can be found in Appendix B.

4. User Research – Findings

4.1. Themes & Insights

In this section the three main themes determined by our research are presented, along with a detailed description of each. The main themes are: cognitive mapping, familiarity with the buildings (on campus), and affective state.

4.1.1. Cognitive Mapping

Cognitive mapping is a process in which humans and animals "gather spatial information and construct some representation of unfamiliar environments, and then utilize this information for traveling in those environments" (Eilam, 2014). It is a process which was very prominent in the data, especially during the scenario description. Here, participants were asked to mentally travel from a room in a certain building to a room in another building.

In the process of cognitive mapping, directional cues and landmarks play an important role (Jacobs & Schenk, 2003). We found that all participants had some form of representation of the campus in their mind, and this representation became more extensive as students' time on the campus progressed (e.g. first year students at the beginning and end of the year). This is consistent with the finding that the construction of a cognitive map happens over time, in a more or less automatic way (Jacobs & Schenk, 2003). Some participants indeed seem to possess a very detailed cognitive map, the presence of which is not really recognized, whilst simultaneously perceived as self-evident.

The above became evident during the interviews. Upon asking "How do you navigate within the campus?", interviewees replies included "I just do", "Just based on my knowledge" or "I just know". A first-year student for example, is less familiar with all the buildings than senior students: "I don't know where the IPO building is." Most of our senior participants were able to navigate through all scenarios, with the exception of finding the Momentum building which was unfamiliar to almost all participants.

Furthermore, participants have some overlap in their representation and definition of landmarks, and the way they use these to navigate through campus. This is illustrated by expressions as "the bridge-thingy" and "weird roundabout". These landmarks provide information on what the cognitive map of a person is based on and what the key elements are in the cognitive map.

Other cues present in the cognitive map are signs within buildings (directional cues), illustrated by quotes as "I don't know where K17 is, but it is probably to the left when entering the building. Then I will look on the sign hanging there". and "I will go up the stairs into MetaForum, and then look for a sign". This suggests that participants are confident that some sort of spatial information sign will be present in an easy-to-find location, though they do not know beforehand what the exact location of the information will be.

Cognitive maps were also used to evaluate what mode of transportation to use: "I will go by bike, so I first have to pick up my bike from under the Auditorium". This suggests that the cognitive map is used for distance estimation,

In conclusion, the cognitive map of our participants includes directional cues, landmarks and distance-related cues. These are used to find the most efficient route and which mode of transportation is most suitable.

4.1.2. Familiarity on Campus

One of the important themes in our thematic map, and also in cognitive maps, is the familiarity with the buildings. This concept is all about the knowledge that a person has about a building; which can be both its location on campus as well as the building's internal layout.

The interviews showed that certain buildings are more generally known to the participants, such as Auditorium and MetaForum. These buildings are most often used and visited during the Introduction week or for general courses, like calculus and physics. Therefore, students will be familiar with at least their location relatively early-on in the year. Furthermore, students are also more familiar with the building that belongs to their faculty; Build Engineering students know Vertigo, Mechanical Engineering students know Gemini and someone from Psychology and Technology is more likely to know the IPO building. In the last example, IPO is furthermore generally unfamiliar to other students.

However, the familiarity with buildings does not only include study-related matters, but also extra-curricular activities like student teams, study associations, sports and other social events like drinks, talks or lectures. For example, we have had only two participants who knew where Momentum, the workshop for automotive student teams, was or even knew that it existed. This was a striking revelation, as many (senior) participants claimed that they knew all the buildings on campus and could find everything if needed. They were apparently unaware of some of the buildings on a campus where they have spent multiple years.

Based on their knowledge of the different buildings and their locations, people constructed different routes in their mind. These routes were not always the most optimal routes with regards to time, distance or difficulty. However, they were selected by the participants due to the fact that they were more familiar with specific aspects of the routes. An example of this was the route given by a participant who walked from MetaForum to Flux through Gemini, because she was familiar with all the different corridors in Gemini.

Another important facet of the familiarity of buildings is being knowledgeable about the internal layout of the buildings. Some of the buildings have a really specific layout where a person really needs to be familiar with the building in order to find the route to a specific room. A good example of such a building is the MetaForum, which has lecture rooms on various different floors that are not logically numbered. Some of the participants mentioned that they were not sure on which floor a certain room was, as can be seen by the following quote "and then the elevator towards the [he believes], 7th floor and check the signs". When students get more familiar with the building and visit it more often they will get more knowledgeable of the layout and will be able to find specific rooms easier and quicker.

4.1.3. Affective State

The user's affective state is an important aspect with regards to the issues faced when navigating the TU/e campus, centring around the feelings and emotions they experience when they are unable to find their way, and how this emotional shift changes the remainder of their day.

From the research it is clear that navigational issues result in a negative affective state, with participants specifying predominantly pessimistic views about their experiences whilst lost, from anger to helplessness. From the wide variety of emotions given, 5 specific reactions were found that encompassed almost all of the views held (disregarding "increased confidence"): stressed, nervous, annoyed, disappointed, and angry.

Four of our participants reported feelings of stress when they narrated their stories, particularly with regards to how it affected the rest of their day, with one stating "[it is] not nice when you have to be somewhere". Coupled with this emotion is a feeling of anxiety (experienced by 2 participants), which can greatly affect their mindset. Alternatively, 3 participants specified a feeling of nervousness and uncertainty with regards to how 'said navigational issue' would affect their studies.

A large proportion of our participants (39%) reported a feeling of annoyance, particularly with regards to the university itself, as they expect a certain level of organisation and information from such a high-ranking university. Similarly, several participants specified a feeling of disappointment at the level of disorganisation present, feeling "disappointed with the information provided by TU/e". Lastly, anger was present in a few participants, who felt irritated at the lack of readily available information regarding the TU/e layout. It is important for us to limit these negative emotions, so that users will have a more enjoyable time whilst on the campus.

4.2. Persona

Figure 1 – Yorinde van de Vorst

4.2.1. Introduction

This is Yorinde van de Vorst. She is female, 19 years old and majors in Architecture, Urbanism, and Building Sciences. As she is in her first quartile of the first year she only follows the general courses for her bachelor. There are about 250 other students in her courses, but she mostly talks and meets with her project partners and her intro "brothers and sisters" which are in total around 15-20 people.

4.2.2. Background

Yorinde is not from Eindhoven, and has a student room in Eindhoven City since the Introduction Week, which she attended in the last week of August. She goes to the campus for lectures and meetings, and sometimes goes to the drink of her Study Association (Cheops). She has not subscribed to a Sports Association yet, as she wants to wait and see whether she can combine this with her studies. She uses her bike to go to campus and to travel on campus itself.

4.2.3. Assumed Knowledge

Because she attended the Introduction Week in August, she knows the general layout of the campus. She is particularly familiar with her own faculty building (Vertigo), MetaForum, and Auditorium as

most of the introductory activities took place there. She downloaded the intro-app, but does not use it very often.

4.2.4. Schedule

On regular workdays, Yorinde wakes up in time to be able to bike to campus. She does not know the location of all the buildings and rooms yet, so she leaves at 8.15am to make sure she arrives on time. Due to her morning ritual and roommates that occupy the shower, she is not able to do anything before she leaves her house. When a change in schedule happens, she only knows this if her introduction brothers and sisters throw this in the group-app as she does not have the time to check OASE beforehand.

Usually, her class starts at 8.45 in Auditorium. She follows lectures in the morning and has her lunch break with some study friends. In the afternoon, she works on a project with her group in the Gemini building.

After this meeting, she continues to work on the project individually until 5.30pm, after which she leaves the campus and goes home. She then does some shopping and prepares a meal for her roommates. If she is lucky, another roommate has already prepared some dinner and she can just join in after her full day of following classes.

In the evening, she watches a movie with her roommates and checks her TU/email. She goes to sleep at 10.30pm, because the next morning she has her lecture starting at 8.45.

4.2.5. Characteristics & Constraints

As mentioned before, Yorinde is somewhat familiar with the campus due to introductory activities in the week prior to her start at TU/e. However, she finds it hard to plan the fastest route possible in a short amount of time. To make sure she does not arrive late in the mornings, the wise thing to do would be to plan her route at home before leaving. As she likes her sleep and does not want to spend her mornings planning routes at home, she does not do this. This has resulted in some last-minute stress while on campus, leading to her strategy to leave a bit earlier to have some time on the campus itself to find her way. Leaving earlier should result in timely arrival, which is something that she highly values. When arriving on campus, she hopes she will meet some of her friends who follow the same class, so that they can go together. When this is the case, there is usually that one friend who either knows where to be and how to go, or has an app ready to look it up. Yorinde herself is never that person and prefers to wait until someone else looks it up. However, when totally lost, she does get her phone out and looks up where to be. She dislikes this, as she must open her web browser on her phone, go to google, find a map of the campus, zoom in, find the building, zoom out, and proceed with her route. Something with a lower number of operational acts would fit her personality better.

Even though Yorinde goes to a technical university, she is not a technology innovator in the sense that she always has the newest devices or apps. She fits better in the description of an early adopter, who understands and uses technologies earlier than the average Dutch person. However, when compared to the general TU/e student, she fits the description of a late adopter. This is also because she is new to the TU/e as well as in Eindhoven, and therefore gets the ‘inside information’ a little later than senior students. She and her fellow first-year students received a lot of information in the first few weeks, and it takes a while to process all this information. Besides that, she still needs to find her place within her studies and settle comfortably in her student room.

5. Requirements

This section details the requirements, in particular two different scenarios: the first scenario tells the story of how Yorinde, the persona we created in the previous chapter, uses the proposed system to get to an unknown building in time for her meeting; whilst the second scenario tells the story of how Yorinde asks the way to find an unknown building and how the route is described using the landmarks.

5.1. Scenario 1

It's 10:35 and Yorinde's Calculus lecture has just finished. It ran 5 minutes longer than usual because some of the smarter kids in front kept asking questions to the professor. She is a bit nervous for her next appointment at 10:45, which is with her Calculus tutor to talk about her interim test, which she failed. However, she found some mistakes in the grading, so there is still a chance that she might pass it. Therefore, she needs to go to the tutor's room, Paviljoen U46.

She exits the lecture room (AUD 4), grabs her coat from the coat rack and wants to go out. One of her friends starts talking about the previous lecture and how handsome one of her intro-brothers is, but Yorinde does not have time for this and tells her friend that she will meet her in the break but needs to go now. She walks towards one of the interactive screens and presses the button for Paviljoen, as she does not yet use her outlook agenda, and as such her student card cannot be scanned. She sees that she has to exit the Auditorium, turning left after she passes Atlas (recognisable by the 'globe'), after which she needs to pass MetaForum (denoted with a 'book'), past the building with the scribbly line on it, and turning left at the roundabout. From here she needs to turn right when she sees the building with the 'sun', and continue along the road until she reaches the 'circus tent'.

She exits the Auditorium at 10:38 at the north side of the building and goes down the stairs to her bike. She finds her bike and starts cycling towards Paviljoen at 10:40. She follows her predefined cycle plan, which she can easily remember due to all the different (and intuitive signs) on the buildings, parking her bike in the Paviljoen bike rack.

She enters Paviljoen at 10:43 and uses the internal signage to find the correct room. She arrives just in time, but has had a positive experience of the journey overall, due to the ease with which she found her way to a new, unknown building.

5.2. Scenario 2

Yorinde has a meeting with one of her classmates so that they can work on a project for one of their courses. Her classmate lives on campus (in the Aurora building) and is also active within the student teams that TU/e has on offer. Yorinde has visited her classmate multiple times, and knows the way to her house. Yorinde thought they were going to meet at her friend's room, so she heads there. She rings the bell multiple times, but her friend is not at home. Yorinde decides to call her classmate and ask her where she is/if she is still able to meet.

Yorinde phones her friend, mentioning that she is at her friend's room, and asks at what time her friend can meet. Her classmate tells Yorinde that she is still working for her student team, but that she will be ready in 5 minutes and that Yorinde can join her in the room she is in (in Momentum), and that they can work there. Yorinde agrees, but mentions that she has no idea where the specific room is. Her classmate decides to give Yorinde directions by phone. Her classmate tells her that she needs to leave the building with the moon-symbol at her back, cycle past the differential-signpost, past the book, and continue past the roundabout so she has the squiggly-magnetism-sign-building on her right. When she reaches a T-junction, from which she can see the circus tent on her left, she must head right

and then take the following left. If she follows this path, she will arrive at Momentum where she will meet her classmate.

Yorinde, who has a slight fear of losing her way, repeats the route back to her classmate to confirm: depart from the moon, past the book and magnet-sign, turn right when the circus is on your left, then take a left and follow the road to arrive at Momentum. Her classmate confirms the directions, and Yorinde sets-off for Momentum. Without too much struggle, she arrives at Momentum, where her and her classmate start working on their project.

6. Ideation

6.1. Concept Development

From the thematic map and the subsequent meetings regarding its characteristics, we decided not to focus on all the themes, but instead chose a few which were considered appropriate for our design. What is not visible in the thematic map is the frequency of recurring themes, although it is an important aspect in selecting suitable themes to focus on.

During the interviews, it became clear that most – if not all – of the participants had some form of cognitive map that included landmarks, rather than building or street names. Additionally, senior students were generally better (and faster) at navigating from one place to another, as their cognitive maps were more elaborate. This aspect emphasises the importance of creating a good cognitive map, helping to reduce travel time between buildings. It also resulted in us selecting first-year students (i.e. those with an under-developed cognitive map) as our target group. Therefore, we aspired to a design that would include landmarks to help enhance the formation of a cognitive map in new students, and in turn, one that would reduce the effects associated with getting lost.

The initial 'Design Challenge' focused on finding a specific room in a building, and as such we included this aspect in our interview scenarios. However, for the realisation of our design, we decided to focus on building-to-building navigation. This was supported by the notion, from our data, that most students expect the signs within buildings to be informative enough to find their way once inside. Also, the opportunity to ask for help is greater within buildings as opposed to outside, where the number of passers-by is significantly smaller.

Therefore, we envisioned a design focused around new students who were only somewhat familiar with the campus and certain buildings, and one that includes aspects to help improve the development of a cognitive map in these students.

6.2. Design Concept

To help achieve our vision, we determined certain goals we wanted to achieve. From the data, we gathered that the cognitive map is dependent on the inclusion of landmarks, therefore, our first goal was to include said landmarks in the design, forming the basis of the design. A higher goal associated with our design was to make new students independent and capable of traversing the campus without a physical map, but instead with a map in their mind.

As such, we decided to mentally replace buildings with landmarks, signifying that a building is not associated with the bricks with which it was built, but instead with the landmark it represents. For example, the Atlas building should be associated with a globe or the world, instead of "the building next to the water, between Auditorium and MetaForum". We assumed that describing buildings via the landmarks they represent would be easier to remember, therefore helping to speed up the cognitive mapping process. As such, we intended the landmarks to be intuitive (e.g. a globe for Atlas, Phi [ϕ] for Flux, a book for MetaForum, etc.).

Along with 'landmarking' each building, we also chose to include an interactive map within each building that showed the landmarks. A student should easily recognise the building they must go to, taking a route from landmark to landmark. Instead of remembering the route as "200m North, then left, then 2nd street right, etc.", it will be remembered as "first go to ϕ, then to the book, then to the globe". Memorising said landmarks should be easier than remembering which street to turn at and after however many meters.

6.3. Prototype/Concept Illustration

The themes determined using the thematic map played a major role in the creation of the concept and the development of the prototype, consisting of elements such as ‘landmarks’, ‘cognitive map’, and ‘familiarity in the campus’. The purpose of the prototype was to embody the themes by familiarising the first-year students with the campus, enriching their cognitive map with landmarks and simple symbols. This idea of representing the buildings, and their names, with corresponding symbols was discussed amongst the group. We considered the creation of a smart-phone application and the use of coloured-light strips, much like other groups, although these were determined to be heavily dependent on technology. Therefore, we wanted the student to cultivate a good habit of using the cognitive map instead of technology.

Our created prototype (shown in figures 2 to 4) is designed to enable a student to find the quickest route to their destination and to help them memorise it easily using the symbols, which in turn will help newcomers easily recognise the buildings and find their way. We have created a prototype which incorporates a map of TU Eindhoven with all the existing legends and old buildings, onto which we have added symbols of the new buildings, rather than updating the map to our requirement. The interactive buttons present the frequently visited buildings, whilst additional buttons have been added to the legend. It is a paper prototype, resembling an interactive screen with the TU/e campus map, along with two ways to interact, either through the use of one’s student identification card or via the touch buttons on the screen. The idea is that the concept is to be placed near the entrance of each building on the TU/e campus.

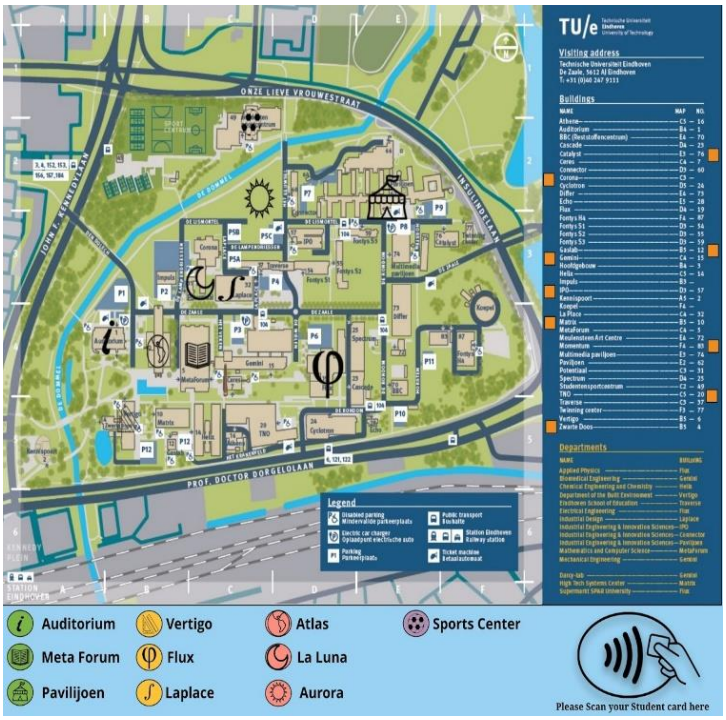

Figure 2 – Interactive Screen 1

One facet of our design is the linking of a student’s agenda/calendar with the student card, allowing the student to scan their card on the bottom right of the screen, which then presents the student with the location of their next lecture/meeting/appointment and gives a corresponding route to the destination (Figure 3). On the other hand, if the student prefers to interact directly with the screen/they do not have their card, they can select their destination using the buttons on the screen, after which a route to their destination is presented (Figure 4).

Figure 3 – Interactive Screen 2 (with Student Card Placed in the Bottom Right Corner)

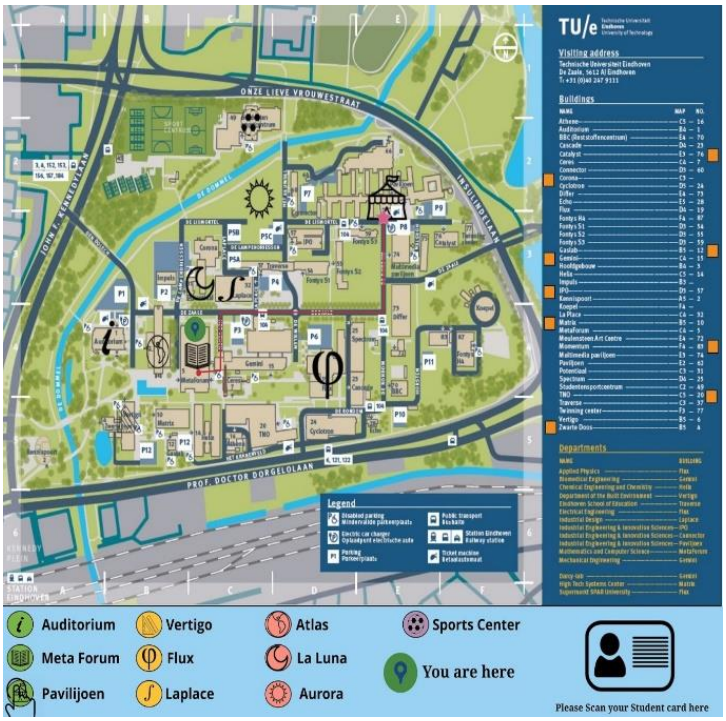

Figure 4 – Interactive Screen 3 (with a User's Finger Selecting Paviljoen and the Route Shown)

The idea behind this prototype is to provoke students to build an efficient cognitive map and nullifying the use of aids to get around the campus (until absolutely necessary). The reason for selecting the paper prototype was to enable the user to visualise the sequential screens and to understand the feedback from the system based on their input. It was also helpful for us to visualise the elements of the interactive screen along with the functionality it represents.

7. Evaluation/Feedback

A design can be considered incomplete without evaluation and testing with the user and, in particular, the integration of this feedback to help improve the design. For our design, we incorporated the user evaluation and feedback to further improve the prototype. Evaluation by the user consisted of a framework designed to gather their reactions, emotions, and insights. Unlike the initial interviews, we did not have a formal data-analysis method, instead gathering the data in a more casual-manner, looking for the interviewee's initial reactions and any suggestions for improvement they had.

7.1. Setup for User Evaluation

The user evaluation is intended to help raise any major issues with the prototype, as could occur during 'everyday' operation, allowing us to fix these issues before it goes into production. As such, we asked participants to interact with the (paper-prototype) interactive screen whilst we questioned them on their thoughts. We interviewed both friends and students within the campus to help gather varied insights and the possible problems that could arise from our prototype.

The following is a short, step-by-step procedural guide on how the user evaluations were conducted.

Step 1 – We present the user with the first screen (figure 2) of the interactive map and waited to see if they could understand how it worked.

Step 2 – We then wait to see if they would use the student identification card scanner or whether they attempt to click the buttons representing the symbol of each buildings.

Step 3 – For this step figure 3 is used, in which a 'current position' marker appears on the map when the card is placed in bottom right corner. We observed whether the participant saw the location marker or not.

Step 4 – Figure 4 is used in this step, in which a route is shown in a bold red colour on the map, clearly linking the required building landmarks.

Step 5 – At this stage we asked some basic questions regarding how the user felt whilst interacting with the prototype, what they liked about it, and what problems they faced.

Step 6 – Lastly, we gathered information regarding the areas of improvement for the prototype.

7.2. Data Collection

The task of data collection was split equally amongst the authors, with each collecting data from 3 participants, following the guide presented above. Each of us collected data from varied age groups in order to test the product's usability and understandability. All the interviews were conducted verbally, so notes were made throughout and key-points were recorded in the form of quotes and emotions described by the user.

The crucial aspect of the data collection was the gathering of new insights into how users interacted with the aid and how it may be beneficial to the users. In particular, we chose to gather initial reactions from users as these tend to be more honest and realistic with respect to its usability. A google document was organised and the gathered anecdotes and insights were incorporated. The insights presented in the next section were formulated and discussed from the notes gathered.

7.3. Data Analysis & Insights

Unfortunately, it was quite difficult to perform an in-depth analysis of the obtained data due to its qualitative nature. Although, we developed insights from the gathered data which, along with various quotes, are presented here. The following bullet-points show some interesting quotes obtained:

- “Those symbols are too strong on the map”,
- “The symbols cover the buildings”,
- “I like the interface with the scanning part”,
- “I like it that it is almost totally offline and that I don’t have to use my phone”,
- “How do I interact with the system?”,
- “Why are there buttons, can’t it be a very big touchscreen?” (regarding the side buttons),
- “What features are provided so that the symbols are visible at night (will they glow) and for foggy days?”,
- “The ‘you are here sign’ is not clear enough”.

Some of the quotes relate to functionality, whilst others relate to its level of interactivity. Each quote can be categorised for further improvements in the design. We would like to highlight the fact that people enjoyed the concept of using such an interactive screen to navigate around the campus, but many had suggestions on how to improve upon the existing prototype.

The participants mentioned the symbols used, the incorporated buttons, and magnification of the screen as promising areas of improvement. We discussed the scenario of integrating buttons within the touch-screen, enabling users to feel and touch their input into the screen. One thought occurred regarding making the entire screen touch-sensitive, which could lead to a more user-friendly interface. The insights gained from the user evaluation clearly showed areas of improvement for the interface, particularly in terms of the symbols used, the clarity of the route, the colour-coding used, and the representations of the landmarks.

During the presentation of our concept, we were asked about the consequences of not linking the student card with the agenda on outlook. This issue could lead to a major setback in the design, as it would lead to the user inputting their destination by hand (although not a major issue). In the case where the user cannot remember the name of their building, then the route showing the name of the landmarks may be confusing for the user, leading to a case of redundant intuitiveness. As such, we may have to present the building-symbols in a 3D or holographic manner for the users to relate to the interactive screen in a better way.

Another major insight is the varying number of entrances and exits to each building, all of which must be mentioned on the interactive map screen. This was mentioned by users, as the entrances to buildings can be very confusing, and incorporation of these might enhance the user understanding of the existing map as well.

8. Discussion & Conclusion

In this section the project and paper are discussed with regards to their successfulness. This is done through a reflection on the design process, followed by the limitations we faced during the project. Lastly, possible future work for the project is presented.

8.1. Reflection

With regards to the project as a whole, we feel we were successful in achieving the task set out: "to launch an investigation of navigational issues on campus, in order to a) better understand the problems people encounter, so that we can then b) come up with ideas for possible solutions". Part (a) of the task is covered in chapter 3, where we conducted interviews to gather information on the problems individuals encountered, and in chapter 4, where we analysed the data to determine the main issues with the current system. Part (b) is covered in the ideation section, chapter 6, which details the development of the concept through to the prototyping stage.

In addition, we introduced the topic, the challenges humans face whilst navigating, and the style of data gathering we undertook initially (chapter 1). We also attempted to support our design approach with the use of literature regarding the role maps and landmarks play in navigation, along with presenting the three research questions which we wanted to answer (chapter 2). Chapter five details the requirements of the system, phrased in the form of two scenarios in which our system is successfully employed. Although not succinctly covering the requirements, the scenarios set out to present solutions to the problems faced in Deliverable 3's scenario (not attached). Lastly, chapter 7 contains a user evaluation study of our prototype, which we undertook to better understand the facets of the design we had not yet considered.

One of the key aspects of the study was our use of semi-structured interviews to gather data on the problems encountered, along with scenarios to help understand the level of knowledge participants had. A semi-structured questionnaire was used to garner a good understanding of the problem, as well as additional information not covered by closed-ended questions, such as the emotions participants experienced when they had a problem navigating. This helped us to comprehend the effects that getting lost can have on an individual. The scenarios were also useful in pointing out the buildings known to almost everyone (MetaForum, Auditorium), and how turning them into landmarks might help reduce navigational issues. Unfortunately, each author was only able to conduct 3 interviews a piece (18 total), most of which were performed with individuals known to the authors, leading to a certain level of biasing in the gathered data.

The development of a persona was useful in helping us envision an ideal first-year student who had not attended the TU/e campus before except on a few rare occasions. Understanding an inexperienced user's social environment, as well as their life on campus and how reliant they are on technology was useful when it came to developing an appropriate concept. However, we initially planned to create a second persona which would encompass an ideal senior-student, one who had been attending the TU/e for a few years and who had good knowledge of the campus layout. Unfortunately, due to the limited time available, we opted for only the first-year persona as this was considered sufficient in describing the main problems encountered.

In a similar vein, the scenarios were useful in visualising where our persona might encounter a problem, their reaction to it, and the solution our concept could offer to help reduce their uncertainty. As it was initially intended that we use two personas, the number of scenarios (both positive and negative) was to be doubled, increasing our grasp of the problems and possible solutions. Regrettably, as only one persona was selected, the number of scenarios we could utilise was far more limited.

During the ideation process, many design concepts were generated and assessed. Initially we discussed the development of a mobile-phone application that could help lead the student around, but we realised that our design should not be reliant on battery-powered technology, as some students either don't have smart-phones or their battery does not last very long. Another idea was to develop a concept based around the embedded, coloured-line system utilised in underground railway stations, which leads to user from the entrance to the exact platform they need by following the correct line. Unfortunately, we found this system difficult to implement due to the number of entrances to the TU campus, the amount of material required to implement such a system on the ground, and the problem of determining the best way to direct users at intersections where two routes could lead to the same place.

With regards to our chosen design, we felt that landmarking the buildings was a cheaper and easier method for implementing an embedded system in the environment, as well as making the buildings easier to discern. Sadly, we were designing our system around the pre-existing building names, which don't have a common theme and which aren't easily identifiable with symbols. As such, the symbols selected were a tad basic, and weren't always logical (such as the use of Phi [ϕ] to denote Flux, as ϕ_B is the symbol for magnetic flux in physics). Our system also relies on each building having its symbol either on top, or high up the side, to aid in visibility from far away. However, certain buildings are low-lying (Paviljoen, LaPlace), meaning it would be difficult to see their symbols from the far-side of the campus.

The final prototype, based around interactive screens that would be placed within the entrance to each building, was developed on the knowledge that the designed concept would still need to be taught to first-time users. As such, it consists of a top-down view of the campus, with the symbol for each (main) building given on the map and at the bottom, along with a list of all the buildings on the side. It is quite basic, as can be evidenced by the symbols appearing in stark contrast to the rest of the map. Additionally, only 10 buildings were equated into symbols. This was mainly due to their prominence as landmarks, but it also resulted from the limited time available, the difficulty of trying to find a symbol for some buildings, and the limited amount of space available on the map.

The user evaluations were useful in discovering the areas where our design was good and those where it was lacking. They were done using a more-structured interview approach, leading the participant through a scenario in which they 'interact' with the screens whilst being asked questions. This was helpful in understanding where our design could be improved, particularly with regards to the symbols used, the clarity of the route, and the use of colour-coding. However, due to the simplicity of the prototype, we did have to explain quite a bit verbally. As such, our prototype is not stand-alone, but requires some form of instruction in its current iteration.

As a whole, the group worked well together, sharing and listening to each other's ideas, as well as questioning one another to help achieve the best concept possible. Communication was done through bi-weekly group meetings and using a WhatsApp group, where each member could ask questions, ask for help, update the group on what they were working on, and present their ideas. A Google Drive folder was also created, where all the documentation could be stored and accessed by everyone. These applications are regularly used by students to keep in contact, and worked well for us. In particular, the use of sub-folders based on week made it easy for us to keep track of the current documents we needed to work on.

Lastly, the research questions presented at the start of this investigation are to be assessed by how well they were answered. The first, "what are the main problems associated with navigating the TU/e campus", was answered during the initial interview stage, where participants complained about the

lack of readily available information on the road, an inability to find the best route, and a lack of familiarity with the campus in the initial stages.

The second question, regarding how these problems affect an individual, was answered using the interviews and literature research. In terms of physical problems, being late was found to be the most common result, as getting lost resulted in increased travel times. With regards to mental attitude, a reduction in confidence was seen, as well as an increase in the emotional strain on the individual. This was supported by feelings of ineptitude, stress, and anger, all of which are detrimental to an individual's well-being.

The answer to the final research question, whether it is "possible to limit these issues?", is (in theory) yes. It must be stated that as our design was not implemented in real-life, we are unable to succinctly answer that question except in theory. In terms of finding the "most proficient method", we cannot say for sure that we achieved this, as there are many different ways to tackle such a task. Although, after discussion of the various ideas we generated, we arrived at the concept we considered to be most suitable for the campus as it is, and one that could be easily embedded in the environment and used by everyone.

8.2. Limitations

In terms of the limitations of our study, there were only a few. Firstly, one of the self-imposed limitations was with regards to the data gathered from the interviews. Although data from all the groups was available online, we chose to only use the data from our 18 participants, mainly as the questions we asked were more useful to our research method and because the time required to analyse all the data would take us too long. However, as mentioned in the section above, this did lead to a certain level of biasing as most of our interviewees were known to the authors, being a part of their faculty. This resulted in a limited view on the problems faced by everyone.

One of the major limitations, imposed by the course itself, was with regards to the time available. With only 8 weeks in which to interview users, foster an understanding of the problems they face, develop an applicable concept and prototype, and to evaluate the prototype with users, there was not much time available for when things went wrong, or for when we wanted to spend longer working on an aspect. This limitation was experienced by all attendees of the course, so it cannot be considered as a limitation our group alone faced.

Additionally, the structure of the course resulted in limitations of its own. Details on the deliverables were given out as they arose, meaning that our mindset was more reactive than proactive. If such information was given earlier on in the schedule, then more time in the early stages could be spent on improving our understanding of the required concept, whilst our design phase could've begun sooner. As a result, we had a fairly limited amount of time in which to develop the prototype, as can be evidenced by the simplicity of the one presented.

8.3. Next Steps/Future Work

In terms of immediate work that could be undertaken to help improve our prototype, PowerPoint or a similar program could be utilised to make the interactive screens more interactive when evaluating them with the users. Instead of using three separate images to denote the various states, one could place each image on a separate PowerPoint slide and, using the various annotations the program provides, provide a more accurate representation of what our interactive screen system does. This

could then be loaded onto a tablet device, where the user could then click or scroll through the images in a more efficient and believable manner.

Two methods could be implemented to increase the usability of the current system. The first of which focusses on the keeping the current labelling system of the buildings and, instead of using symbols, it could incorporate colour-coding the buildings, which negates the lack of logical symbol choice. However, users with colour-blindness would have difficulty, so the chosen colours should be distinct and perhaps contain patterns to make them easier to discern.

The second method to help improve the current prototype is the development of a new building-naming scheme, one that is developed alongside a distinct pictorial system. One issue we faced was selecting images that not only coincided with building names, but which were also similar in style to one another. As such, one area of future work would be on developing a distinct system which would clearly denote each building as well as keeping in the style of TU/e.

Lastly, one feature we negated in our research was the navigational aids offered inside buildings to help find specific rooms. Although this system is currently quite useful for inexperienced students, the fact that the labelling system can change between buildings is a bit confusing. As such, development should be done on creating a clear and consistent labelling system for within the buildings, such that someone who hasn't been to the building before can find their way easily and quickly.

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10. Appendix A – Interview Guide

This guide contains information for the interviewer, the questions to be asked, and the developed scenarios. The interview is expected to last a maximum of 30 minutes and should be recorded for future references. Each interviewer is to interview three participants aged between 17 and 60 years, of either local or international background. It is encouraged to interview people of different demographics to gain a variety of perspectives on the navigational problems.

a) Questions

1. What is your gender?
2. How old are you?
3. What is your profession?
4. What is your main reason for visiting the TU/e campus?
5. What are the other reasons for your visits?
6. How often do you visit the TU/e campus?
7. How do you navigate within the campus (what method)?
8. Which buildings are you familiar with?
9. Have you ever encountered any problems whilst navigating through the campus?
   If so, please give an example of what happened and how you solved it; if not, what would you think a problem may arise from?
10. How did the problems you encountered whilst navigating make you feel?

NB: More information can be given by interviewee, record it all.

b) Scenarios

The following is a list of scenarios (routes) to present to the participant, in which they are to be asked how they would navigate through each. The interviewee may not be familiar with all the routes given, and as such may give a negative response. This should be noted along with their reason for not being able to complete the route.

Describe how you would navigate the following scenarios:

a. **Sportcentrum Fitness Room 1** (aka gym) to **MetaForum 15**
b. **Auditorium 10** to **Paviljoen K17**
c. **IPO 0.98** to **Matrix 1.15**
d. **Gemini-Zud Collegezaal** to **Flux 3.109**
e. **Vertigo** to **Momentum**

c) Maps

To be used alongside the scenarios, with figure 1 for the participant and figure 2 for the interviewer.

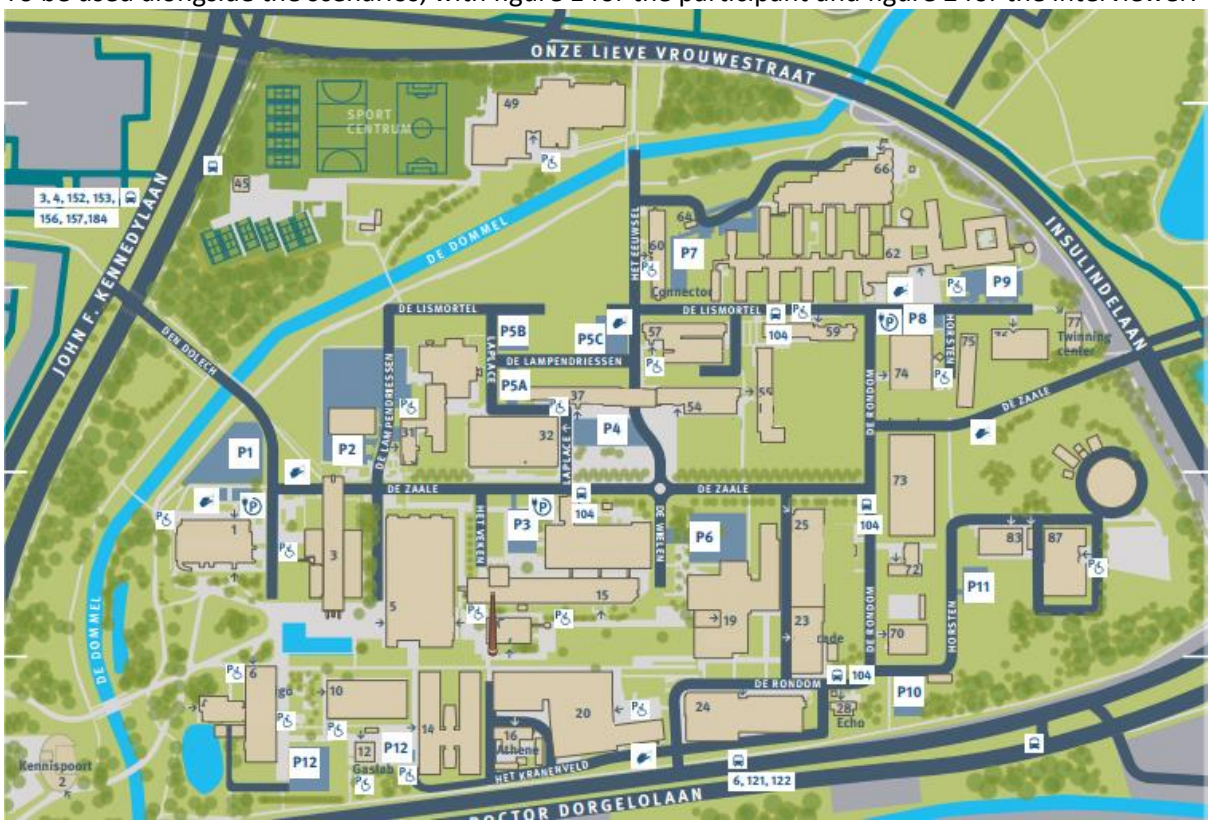

Figure 5 – TU/e Campus Map without Building Titles

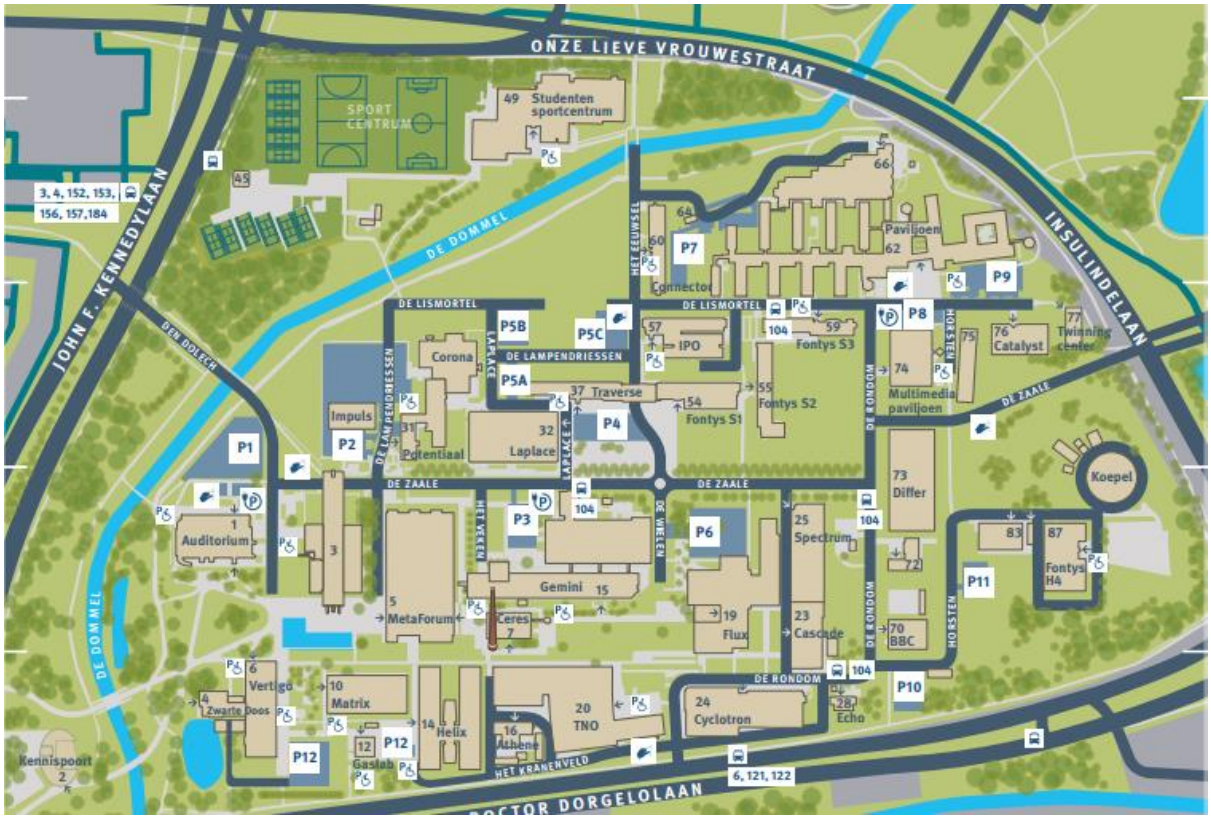

Figure 6 – TU/e Campus Map with Building Titles

11. Appendix B – Thematic Map

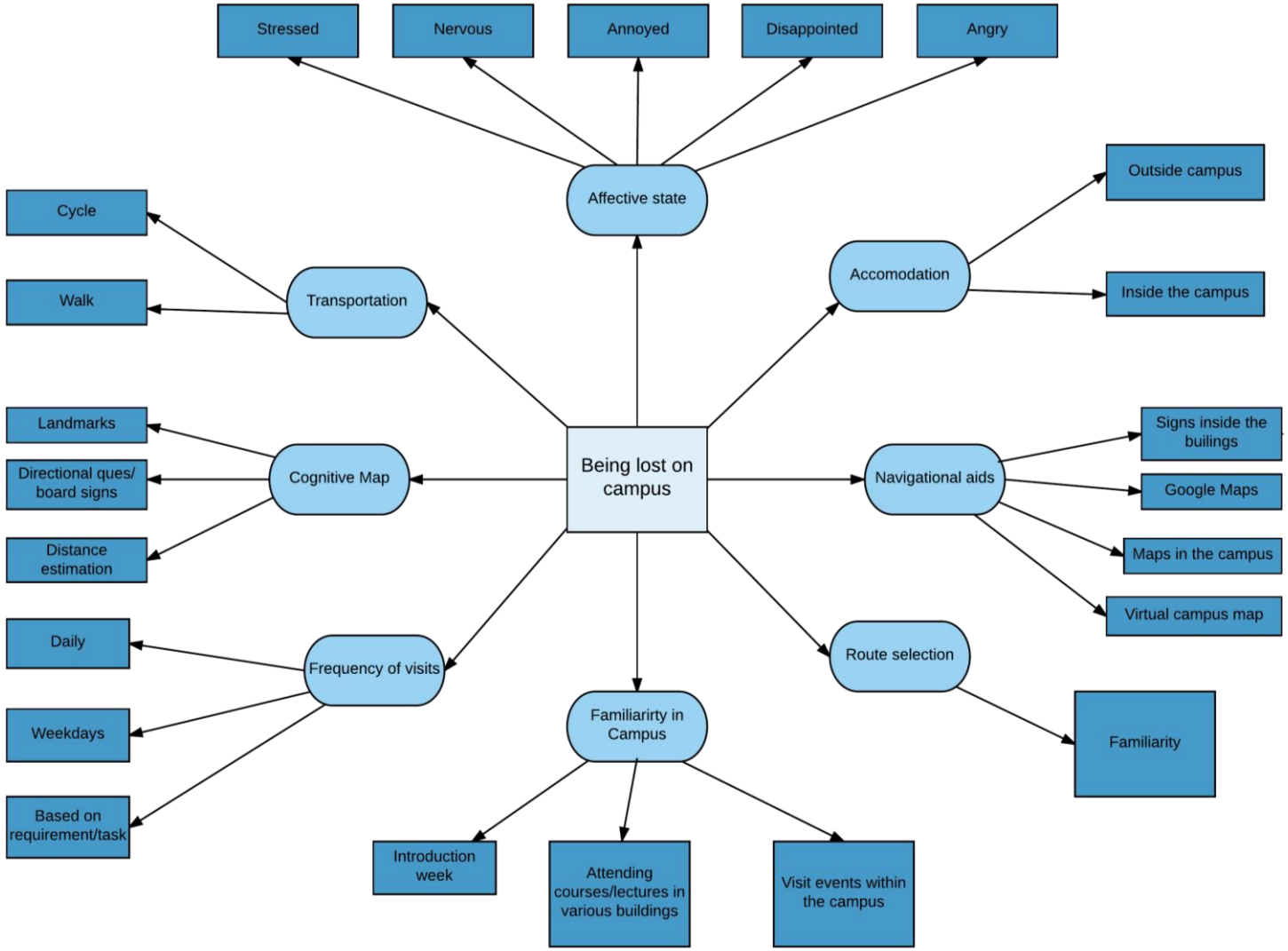

Figure 7 – Thematic Map developed from User Data