Improving cycling experiences on bicycle highways in Zeeland

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Abstract

Everyone in the Netherlands cycles. Still, not every bike commute in the Netherlands is engaging and enjoyable. Even with the advent of bicycle highways, which are supposed to make commuting by bike more accessible and time-saving, still too many people are commuting by car. The Dutch municipality in Zeeland wants to encourage commuting by bike instead of commuting by car as much as possible. The bicycle highway is one of its initiatives to promote and encourage cycling. However, it is still very common for people to dread the prospect of a boring, windy, rainy bicycle ride, despite the fact having access to such comfortable bicycle highways. A solution needs to be found that can improve the cycling experience and bicycle usage on the bicycle highways in Zeeland.

Thus, the research question states: *How can the cycling experience on bicycle highways in Zeeland be improved with the help of engaging technologies to increase bicycle usage and promotion of cycling?* With the following sub-questions:

- *Sub 1:* What types of technologies can be used persuasively and engagingly?
- *Sub 2:* What factors influence cycling experiences and cycling frequency?
- *Sub 3:* How can designing a technology contribute to encouraging and promoting cycling?

A literature study was done to gain more insights about coming up with a possible solution for this problem. One possible solution proved to be the use of gamification, where persuasive and engaging technologies can be used to motivate the users. These techniques were further investigated to back up this thesis. To structure this research, the Creative Technology Design Process was used, where the main idea is to create a more iterative design process with steps that do not follow a specific order, consisting of ideation, specification and realization. During the ideation, two designs were made, one for an application and one for a led screen. Product requirements also have been established. Next during the specification, the product requirements were specified. Finally, a survey was conducted to see whether the two designed prototypes would contribute to the increasemnet of bicycle behavior. 42% Of respondents agreed that the proposed app would increase their bicycle behavior. As for the led screen, only 31% of respondents agreed that it would increase their bicycle behavior. The main point of critique was the concerns about privacy because LED screen projects names data publicly.

Based on the results of the survey, the app and the LED-screen content were redesigned. The app was redesigned to have a more professional design, more competing elements and information was cleared up to make the user experience more intuitive. For the LED-screen, also a more professional and subtle design was made, as well as more privacy choices and more interface variations to keep the users curious.

Finally, it could be concluded that by designing a digital mobile application and a physical LED-screen, together with offering real-life rewards that, when combined, engage and motivate users to increase bicycle usage and promote cycling.

The main discussion point of this research is that no respondents living in Zeeland had responded, however bicycle behavior in the Netherlands is comparable, so the results can be reflected on the situation in Zeeland as well. Additionally, it is assumed that the new app and LED-screen give better results than the version of the app that was evaluated. To properly test this, real-life situation tests would have to be conducted to get a good insight into this.

Acknowledgments

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1 Introduction

This chapter will describe the background of this graduation project, after which the challenges will be discussed. Furthermore, the research questions will be stated. At the end of this chapter, the structure of the report will be outlined.

1.1 Problem

Everyone in the Netherlands cycles. It is, in contrast to other countries, seen as a common and self-evident mode of transportation (Van Duppen & Spierings, 2013). However, still not every bike commute in the Netherlands is engaging and enjoyable. Even with the advent of the bicycle highways, which are supposed to make commuting by bike accessible and time-saving, this problem is still not solved. Bicycle highways are cycling lanes that offer wide cycle paths without many curves, few traffic lights and few intersections, making commuting more convenient and comfortable than regular cycle paths (ANWB, 2019).

The Dutch municipality in Zeeland wants to encourage commuting by bike instead of commuting by car as much as possible. It is an important topic in their political campaigns and they believe that cycling is the ideal way to experience Zeeland. That is why the municipality invests in innovative concepts to stimulate bicycle use, one example is building a bicycle highway (Kernteam PVVP, 2016). Zeeland is an important bicycle municipality, which they want to further improve and strengthen and therefore they reflect this in almost all of their programs and policies. The bicycle highway is one of the municipality's initiatives to promoting cycling.

However, it is still very common for the inhabitants of Zeeland to dread the prospect of a boring, windy, rainy, or long bicycle ride, despite the fact having access to comfortable bicycle highways. This makes it difficult for the municipality in Zeeland to efficiently promote cycling and the number of people commuting by car could potentially turn into a larger problem shortly. To prevent this from happening, a solution needs to be found that can improve the cycling experience and can increase the bicycle use of the bicycle highways in Zeeland.

1.2 Challenges

This solution should take multiple challenges into account since this research is done in collaboration with the municipality. Firstly, it is important to keep in mind that the solution needs to be easy in maintenance. It will not be possible to entirely cover the bicycle path or use materials that need much maintenance, like glass or wrought iron. Secondly, the solution must not contribute to extra light pollution of the city. Light will be built into the bicycle path to prevent this. Thirdly, social safety needs to be taken into account to provide safe and comfortable commuting.

1.3 Research (sub)questions

The problems and challenges above have led to the following research question:

- *RQ:* How can the cycling experience on bicycle highways in Zeeland be improved with the help of engaging technologies to increase bicycle usage and promotion of cycling?

The question above can be further divided into the following sub-questions:

- *Sub 1:* What types of technologies can be used persuasively and engagingly?
- *Sub 2:* What factors influence cycling experiences and cycling frequency?
- *Sub 3:* How can designing a technology contribute to encouraging and promoting cycling?

1.4 Structure of the report

The chapters in this report will try to answer the proposed research question in the following way. Firstly, the State of the Art will present relevant literature and developments related to the research question. Secondly, methods and techniques will be explained. Thirdly, the ideation will be discussed and the design process is started with the help of brainstorming and scenarios. Next, in the specification chapter ideas will be further developed, the prototypes, tests, and design decisions throughout the project will be shown. Furthermore, the realization chapter is the chapter where a single idea will be developed and worked out. Finally, conclusions will be drawn and problems will be discussed. The discussion will present comments on the process and recommendations are proposed.

2 State of the Art

In this chapter, relevant literature and developments related to the research question will be presented. First, the importance of cycling as transportation will be discussed, as well as the factors that contribute to bicycle usage and promotion. Then, an overview of engaging and persuasive technologies is given and ways of possible contribution to answering the research question. Lastly, technologies that currently are helping or possibly will help in this project will be discussed.

2.1 Commuting by bicycle

2.1.1 Cycling as a transportation mode

The bicycle is a popular transportation mode, especially in European countries. Cycling has many advantages for society as well as for the commuter itself. Cycling is often cheap, easy and environmentally friendly. However, cycling also has a lot of downsides such as its carrying capacity, being exposed to all kinds of weather and more vulnerable in traffic. The Netherlands is universally known as the world leader when it comes to cycling levels, where 16% of the total road network is dedicated to cycle paths and where a third of all trips under 7.5 km are cycled (Fishman, Böcker, & Helbich, 2015). The good bicycle infrastructure of the Netherlands has had a major influence on these numbers. They started investing in this structure since the late 1970s when the oil-crisis and concerns about the downside of car use sparked an interest in non-motorized vehicles and transportation. During this time, the current cycling network almost doubles in size and nowadays almost all Dutch cities and villages possess a well-developed bicycle network (Martens, 2004).

Most research concerning transportation and commuting use the standard framework that focuses on travel time as the cost of moving from origin to destination, classified by the five most important “D-variables”. This being density, diversity, distance to transit, destination accessibility and design, stated by Ewing & Cervero (2010).

- Density

Density is measured as the variable of interest per unit. The area can be gross or net and the interest can be a population, employment or building floor area.

- Diversity

Diversity measures the number of different land uses in a given area and the degree of their representation in the earlier mentioned areas and interests.

- Distance to transit

Distance to transit measures as an average of the shortest routes and streets from the origin to the destination (this specifically being a train or bus station.) It can also be used to measure the transit route density between transit stops of the number of transit options in a certain area.

- Destination accessibility

Destination accessibility measures the easy accessibility to trip attractions, locally or regionally. Regional accessibility is defined as the distance to the central business district and the local accessibility is defined as the distance from one's home to the nearest store.

- Design

Design includes the street network characteristics with a specific area, for example, average block sizes, the number and proportions, intersections or the sidewalk coverage, average street widths or other physical variables that differentiate pedestrian-oriented environments form car-oriented ones.

2.1.2 Factors that influence bicycle usage

Cycling is a good option for many commuters because it is cheap, healthy and environmentally friendly. To understand why people choose to commute by bike, factors that influence bicycle use have to be found. According to Rietveld & Daniel (2004), factors that influence bicycle use can be grouped into four different categories; individual characteristics like income, age and gender. Socio-cultural factors like cultural background, ethnic origin and political preferences. Then there are also the factors associated with the bicycle as a mode of transport and factors that are a consequence of other modes of transport. Additionally, Xing, Handy, & Mokhtarian (2010) agree with the previously established factors, but state that the physical environment factors such as distances and safe destinations have a big impact on the cycling frequency. Issues such as non-usual weather conditions or steep slope and the build environment are also very important (Barberan, e Silva, & Monzon, 2017). Of course, psychological factors, like norms and habits either contribute or prevent bicycle use, stated by Heinen, Van Wee, & Maat (2010).

Looking at all these different factors, the conclusion can be made that the most impactful categories on using bicycles as a mode of transportation are social, demographic, physical environment and economic factors, illustrated in the figure below.

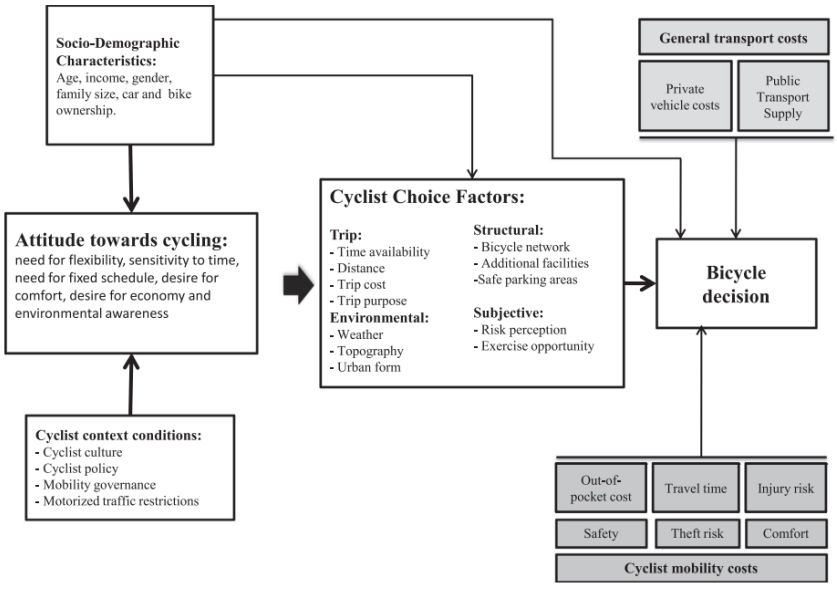

Figure 1: Conceptual model of factors affecting bicycle use (Fernández-Heredia, Monzón, & Jara-Díaz, 2014)

2.1.3 Cycling promotion

When designing a cycling experience, it is important to understand that attitudes and experiences towards cycling promotion have a huge impact on the efficiency of pro-bike policies. Pro-bike policies can raise awareness for cycling with the help of encouraging campaigns, infrastructure improvements and facilities enhancements or other interventions that lie the focus on the positive aspects of cycling. Cycling for transportation or recreation purposes could be increased by enlarging the cycling network or improving the cycling infrastructure to increase cycling safety. Xing, Handy, & Mokhtarian (2010) give examples of possible campaigns that could encourage cycling, like creating promotional events such as ‘‘bike to work day”, publicizing of high-profile role models.

In fact, Rietveld & Daniel (2004) state several factors that could contribute to biking promotion. The biking efficiency can be improved by avoiding traffic problems, asses to parking areas, door to door transport. There can be more flexibility, such as no time or frequency restrictions. Economical changes can be made, like no fuel expenses, the purchase and maintenance of the bicycle paths. Ecological modifications should be done to reduce the emissions of greenhouse gases. The health benefits should be emphasized and the fun that some users take pleasure cycling needs to be recognized.

2.2 Engaging and persuasive technologies

Technology can be very useful when designing and improving the cycling experience. Navarro, Gay, Golliard, Johnston, Leijdekkers, Vaughan, & Williams (2013) believe that mobile devices and applications offer a great opportunity to contribute to a positive attitude towards citizens, encouraging them to form new habits around alternative forms of transport. Technology can be used to provide the users with accurate route information and location/availability of facilities near the destination, access to social information and being able to network with other riders and gamification or other entertainment elements to make the app successful.

2.2.1 Gamification

One popular technology that can help improve experiences is gamification. Gamification aspects could motivate and encourage cyclists to cycle more often due to their engaging nature (Deterding, Sicart, Nacke, O'Hara, & Dixon, 2011). During their study, Navarro et al (2013) found that gamification is a big aspect in keeping the users interested and in wanting them to ride more often. Their research stated that interviewees were interested in rewards whilst cycling, in playing against friends and seeing their position on a leaderboard, in completing quests and in exploratory features, such as discovering restaurants and cafes around them. Many of them mentioned that cycling would be more fun if the application could be used to display and discover new places.

This discovery is confirmed by Barratt (2017), who saw that one of those popular mobile applications called Strava has a strong parallel between the key features of the app and the gamification elements. These mechanisms have a persuasive influence on the cycling practice of the users. This is done via the gamification process, applying game mechanics and game design to motivate people to achieve their goals and compete against others.

Both persuasions through push messages and competitiveness against friends are two big factors encouraging cycling. The use of gamification keeps the users engaged and interested in their exercise and encourages them to take the bicycle instead of a car. In the figure down below, an illustration can be seen where the content of the encouraging and engaging aspects of technology design is explained.

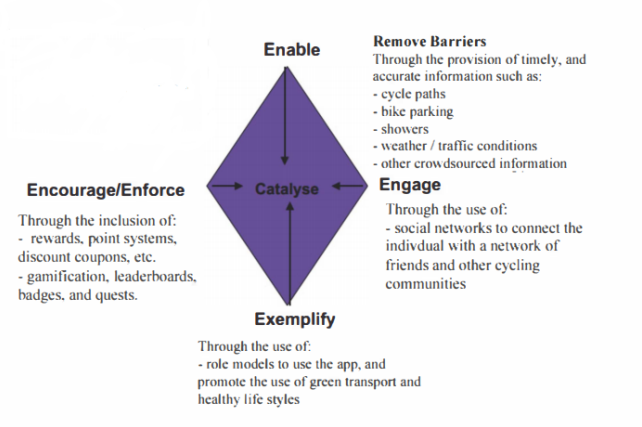

Figure 2: Personalization in Social Cycle

Besides, during research Wunsch, Stibe, Millonig, Seer, Dai Schechtner, & Chin (2015) found that another strategy to encourage low urban mobility such as cycling and walking is a 'bike buddy'. program. This is a socially arranged bike ride to help less experienced bikers overcome initial barriers towards biking. With the help of technology, bike buddies and participants were matched based on where they live and what routes they usually take. Their test subjects reported a positive experience with their bike buddies and perceived this strategy to be valuable for new bikers. Barratt (2017) states that because of today's cycling computers, GPS units, computers, smartphones and applications, a bike ride is no longer something that just happened, a memory, a calorie deficit to be annulled. It now is a record in training, time, or score on a leaderboard, a route that's shared with friends and/or strangers. Because of a (digital) achievement manifest, the cyclists are more motivated and the manifests are also enhancing cycling experiences like seen in the Wunsch et al (2015) research.

It is important to recognize that the most effective way to influence the cyclists' experiences with the help of technology is to introduce digital achievement and offer engagement with other player's on online platforms. This gives the bikers a sense of progress and competitiveness, increasing their joy for cycling and therefore positively influencing their biking experience.

2.2.2 Persuasive and engaging technology design

Technology has always influenced human society and behavior. However, this influence is often unintentional or accidental. Berdichevsky & Neuenschwander (1999) give the following an example of a technology that unintentionally has had a lot of influence:

"For example, automobiles and highways helped create the American suburbs, but they were not invented with the intent of persuading tens of millions of people to commute to work every day." (p. 51).

Persuasive technologies can be found in every field, from education, healthcare, marketing and safety. But how do these technologies change attitudes or behaviors? It is important to know that persuasive strategies are not something new, they were already used way before the rise of computers and technology. Although computers did not introduce humans to persuasive strategies, it has boosted the opportunities of persuasive strategies, by facilitating role-playing and providing people with virtual environments or simulated situations (King & Tester, 1999). They have found five main strategies that are used by technology to achieve persuasion.

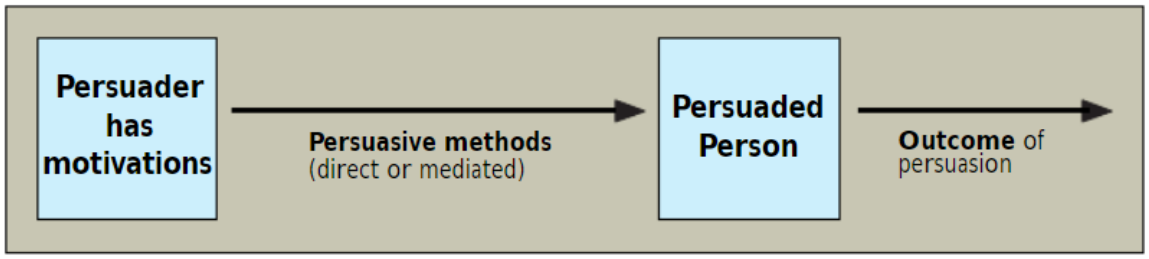

Figure 3: Framework for persuasive interaction (Berdichevsky & Neuenschwander, 1999)

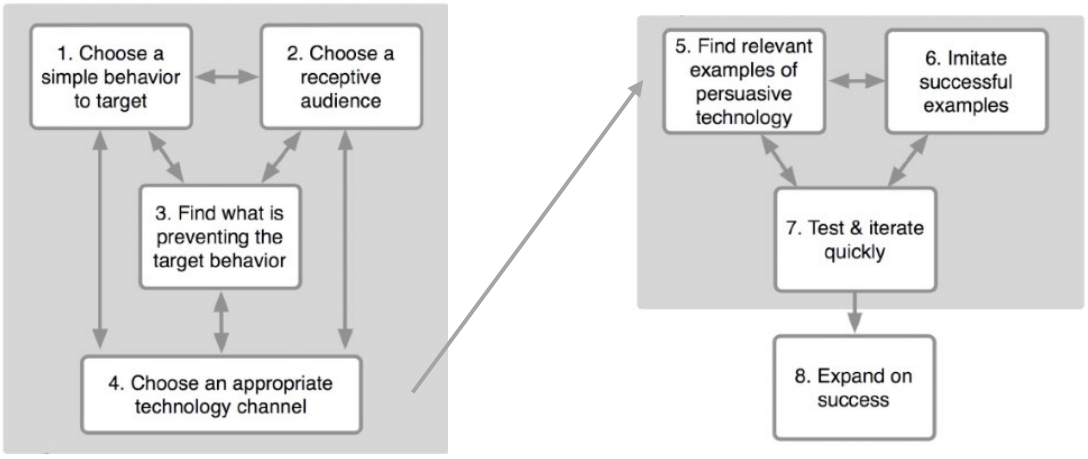

Figure 4: Eight steps in early-stage persuasive design

User engagement and effectiveness based on technological inventions can be achieved through a various set of interventions methods and support features, profiling and personalization. Chang, Kaasinen, & Kaipainen (2012) give the following criteria. There needs to be profiling and personalization, meaning that information is collected to profile the user and tailor the output based on the users' needs and characteristics. The design needs to have a holistic approach, meaning that there needs to be a wide spectrum of health like physical, mental and social aspects. There also needs to be social support, meaning that the design needs to consist of certain social support features that play an important factor in the psychosocial wellbeing of the user. This will increase user engagement in these technology-based inventions. The figure below illustrates a framework for users' attitudes when designing persuasive and engaging mobile applications.

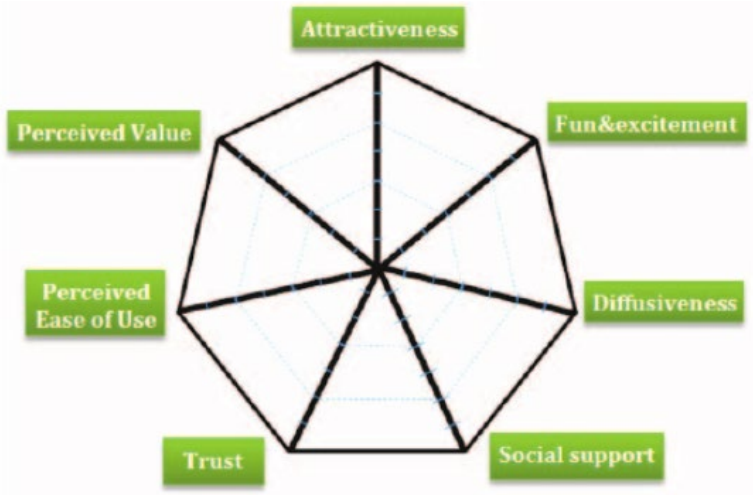

Figure 5: Framework for designing persuasive and engaging technologies (Chang, Kaasinen, & Kaipainen, 2012)

2.2.3 Designing a cycling experience

A lot of research has been done to understand the quantitative terms of cycling such as fields of travel behavior, transportation planning and health sciences that examine the determinants of cycling. Yet, there exists less research that offers an understanding of the qualitative experience of cyclists. (Koglin & Rye, 2014).

The fact that the classic factors which determine transport user behavior, such as cost and time, are not as helpful when it comes to bicycle commutes use as they are for other modes of transportation. This may indicate that these other kinds of factors of a psycho-social type gain importance in the correct characterization of cyclist behavior, stated by Fernández-Heredia, Monzón, & Jara-Díaz (2014).

When designing a cycling experience, three main categories need to be taken into account: the social, sensory and spatial phenomenon. The elements of each category are explained in figure 1 below. (Liu, Krishnamurthy, & van Wesemael, 2018).

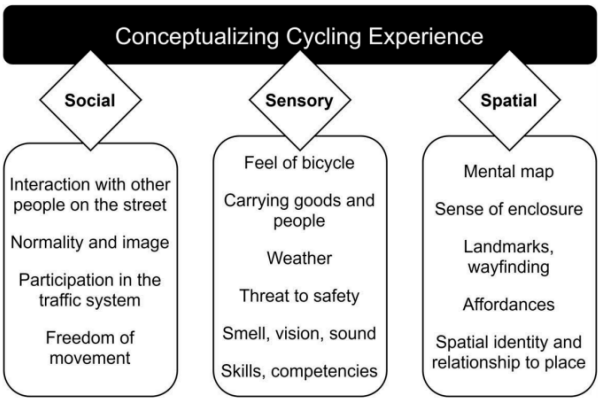

Figure 6: Conceptualizing cycling experience as social, sensory and spatial phenomenon (Liu, Krishnamurthy, & van Wesemael, 2018)

This conceptualization allows designers to get a deeper understanding of the cycling experiences of cyclists and it gives them valuable quantitative information to strengthen the "design" aspect within cycling research based on the five "D-variables".

2.3 Related work

This section will give an overview of existing projects and products that are related to this research. Useful information can be extracted from what has been done in this area. In the sections above literature was used, however, the results below were found by using a regular search machine a commodity search engine.

2.3.1 Physical examples

First, a set of physical examples in the gamification and cycling domain will be explored. Several examples will be explained in the next sections.

2.3.1.1 SuperZOOkelsti

This cycle route tracks and enhances security and motivates local school children to bike to school and remember their bike helmets. The so-called "SuperZOOkelsti" is a 2.3 km long bike path and takes the cyclist past 9 different animals up to 2.2 tall, which light up in different colors. All the cyclist needs to activate the chip on the SuperZOOkelstien's website is a special chip in a bike helmet. The cyclist can choose between six different light shows and they can also program their own light show.

Figure 7: SuperZOOkelstien cycle path (cyclingsolotions.info)

What can be taken from this example is that the users of SuperZookelsti are in control of their light show (which is then the experience). They are even able to program a light show themselves. The added value of the chip in the helmets makes this personalization possible. As seen in the literature, this personalization aspect is very important when designing an engaging and persuasive product.

2.3.1.2 Bicycle counters

Bicycle counters can be set up in urban spaces and are placed for cyclists to see how many cyclists have been counted that day over a given period, for example, during a specific month. This is an easy way of showing cyclists that their bicycle trip counts. The counter can also be used to show other information such as the time and the temperature. At the same time, the local authority gets an on-going bicycle count on a given stretch.

Figure 9: Bicycle Counter (cyclingsolutions.info)

Figure 8: Bike display Enschede (q-lite.com)

What can be taken from this example is the visualization of important data to the users. This visualization makes them realize that they are one of a kind and unique. When using this example and taking it further by personalizing it, again this persuasive and engaging element will contribute to an improved cycling experience.

2.3.1.3 GameLight

GameLight is a smart bicycle light which projects a virtual game on the ground of cycling paths, within the user's natural field of view while cycling. The system aims to enhance the cycling experience by using augmenting element presented in two different game modes: an "Arcade" mode that implements a virtual coin collecting mechanic, and a "Challenge" mode that provides timed effort challenges. The system consists of a pico-projector and mobile phone wirelessly connected. Speed and heart rate sensors serve as input to the virtually projected game to achieve a fun and playful effect while cycling in a controlled environment.

Figure 10: GameLight (Zhao Lee, Tan, Dancu, Lui, Shen, & Mueller, 2019)

This example illustrates the performance of gamification. Because the environment surrounding is used to projection on, the user keeps its trust in the technology because he can see his familiar surroundings. The application shows projected images on the ground, which are in the line of sight of cyclists and this way the safety of the user can be preserved. Shown in the literature, this is a very important aspect.

2.3.2 Digital examples

Next, a set of digital examples in the gamification and cycling domain will be explored. Several examples will be explained in the next sections.

2.3.2.1 Trappers

Trappers is an application and service which companies can request. It focusses on motivating employees to come to work by bicycle. The actual bicycle use of employees is measured and directly converted into value points, so-called Trappers. With these Trappers, employees can save up for nice gifts in the Trappers shop. The shop has a wide range of fun items, day trips or gift cards from various providers.

What can be taken from this example is the focus on providing such a service for companies, to address and motivate many people from the same company at once. It also works because there is a big possibility that employees are going to compete with each other, emphasizing the competition element.

2.3.2.2 *"Cycle to your work day"*

This is an initiative that stimulates that employees commute to their work by bicycle, on a specific day in the year. With this project, the emphasis lies on making healthier choices and raising money for a charity, in their case "cycling out of poverty". When employees want to participate, they are obligated to sign up on the website where they then can donate a certain amount of money to the charity.

What can be taken from this example is that people do not always have to be motivated by something they only can benefit from. By looking at the cycle to your work example, many employees will sign up because this way they will be contributing to a better world, making them feel satisfied.

2.3.2.3 *Smart in Twente*

SMART (Self-Motivated And Rewarded Travelling) is a handy, free app that helps you travel smarter and more consciously from, to and in Twente. With SMART you can earn points by traveling smartly. These points can then be redeemed in the SMART webshop. They focus on providing information about for example avoiding traffic jams. Users can also earn points by taking part in fun challenges. They focus on reduce travel costs, save travel times, traveling more environmentally conscious and more exercising.

What can be taken from this example is the element of competing in teams and earning points in taking part in challenges, either individually or in teams. Another part is the focus on providing actual traffic and transportation information, making the application very versatile and multi-purpose.

2.4 Conclusion

This state of the art showed that there are a lot of aspects that need to be taken into account when designing an engaging product that will enhance and improve a cycling experience. Sufficient research on the reason behind the use of specific game elements in this particular context is available. However, there is a lack of information about using technology to design an experience for cyclists in particular. Features that will be used in the next chapters are persuasive design steps and the three phenomena social, sensory and spatial. Another thing that is missing is the combination of physical and digital motivation and gamification motivation. That is why in the next chapters, a possibility to combine these two gamification forms can be combined to form on

3 Method and Techniques

In this section, the general structure of the project is explained. The methods and techniques which will contribute to answering the research question will be described. These are part of a specific design process called the Creative Technology design process. The next chapters of the report will be described.

3.1 The Creative Technology design process

"The Creative Technology Design process" is a creative process that is used during the execution of the Creative Technology research project, found by Mader and Eggink (2014). The process is described as a flow diagram where the main idea is to create a more iterative design process, with steps that do not follow a specific order. This way, the design gets non-linear structure and the chapters more will be more intertwined and relevant to each other. The structure can be seen in figure 11 below.

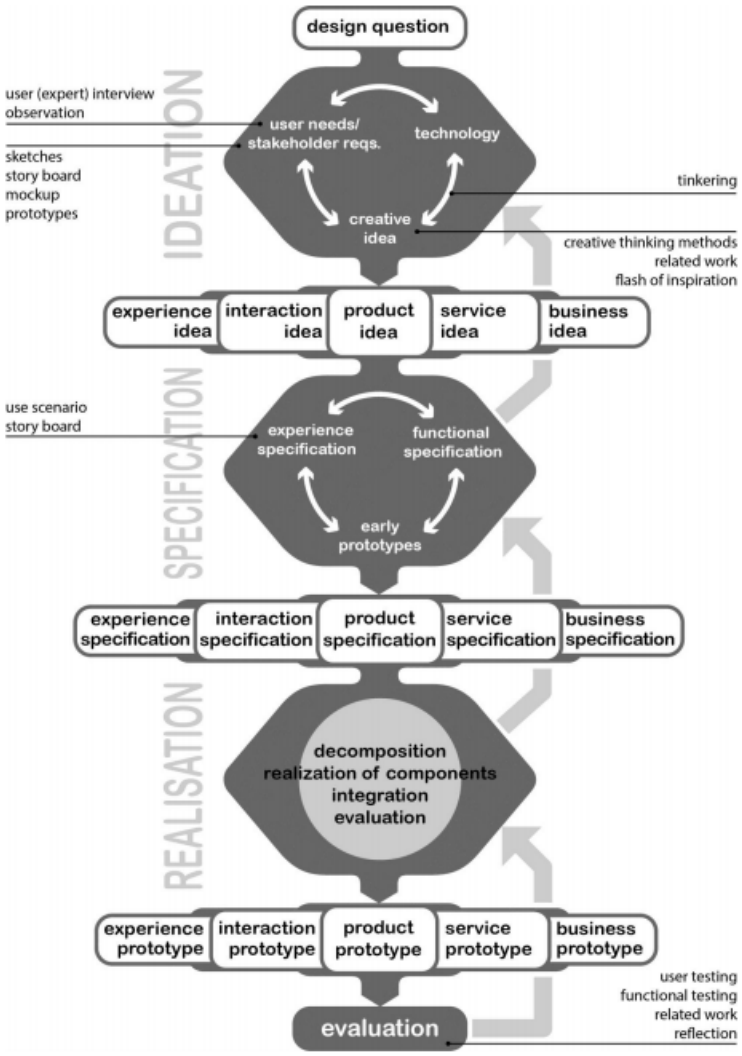

Figure 11: Overview of the Creative Technology Design Process (Mader & Eggink, 2014)

3.1.1 Ideation

In the first phase, the ideation, tackles the problem definition, acquisition of relevant information and idea generation with similar approaches. Early ideas will be evaluated with clients or users, and similar techniques as other user-centered design techniques will be applied. Mock-ups, sketches, user scenarios or storyboards are used to do this. Interviews with clients, users or user experts will give insight into the needs of the target group and will contribute to describing the problem settings and needed requirements.

3.1.2 Specification

In the second phase, the specification, several prototypes will be produced to explore the design space and a short evaluation and feedback loop is applied. For Creative Technology graduation projects, these prototypes will not be made physical, and will rather be well-developed ideation concepts.

3.1.3 Realization

In the third phase, the realization, the specification is being realized. This is done by decomposing the elements of the specification where the components, integration of these components and evaluation will be realized. After every component is put together to form one final prototype, it will be tested and the feedback will be implemented. The requirements for solving the research problem will be proposed and described, and the methods and technologies that contribute to the final prototype are described.

3.1.4 Evaluation

In the fourth phase, the evaluation, the realized prototype will be evaluated on how effective, and functional it is. This is done through user testing. Furthermore, a conclusion and discussion will be conducted.

4 Ideation

In this chapter, the ideation phase of the Creative Technology Design Process is described. A product idea will be generated with the help of user assessment, stakeholder analysis, technology requirements and scenario design. Product requirements will be drawn up and a concept generation will be done.

4.1 User

To get a better understanding of the future users of the newly invented product, user characteristics, user requirements and scenarios need to be established and specified. When the user needs are defined, the problems, goals and preferences can be understood better, resulting in a better designed and more impactful product. The three main user needs that this research focusses on are convenience, safety, engagement.

4.1.1 User characteristics

To be able to design a product or experience that comes across right for as many different groups of users as possible, user characteristics need to be established. The table below shows an overview of the characteristics of the users and possible prosperities the solution might have. The prosperities of the potential users were found in the detailed development overview offered by Juust. The plusses and minuses in the table indicate how well the prosperities fit the profiles of the potential users, this makes comparing between prosperities and profiles easier.

Table 1: User characteristics

		Prosperities of potential users						
Types of potential users		Frequent user of cycle path between Terneuzen and Sluiskeel	The user of the cycle path is unmotivated to commute by bicycle	User mostly uses transportation modes other than a bicycle	The user is commuting either for work or school	User dreads the prosperity of a long bicycle commute	User cycles with company	User is aware of environment-tal impact of cycling
	A worker at industry area Sluiskeel	++	++	++	++	+-	+-	+-
	E-bike user	++	+-	--	++	--	+-	++
	People cycling for exercise	+-	--	+-	--	--	+-	++
	Tourist on bikes	--	--	--	--	--	++	+-
	Schoolkid	++	+-	--	++	++	++	--

4.1.2 User requirements

User requirements are made to be able to check whether the designed product fulfills the demands of the users. With this project, several user requirements need to be taken into account. The first requirement is that the designed product must be easy in use and it should be easily accessible. This to make this the threshold for acquiring the product as low as possible, so that much product use can be guaranteed. The second requirement is that the product must be safe to use or be engaging during a cycling commute. It should not produce extremely unexpected sound or visuals because this could potentially scare the users resulting in a possible unsafe commute. The third requirement is that the designed product should be easy to low cost. This again to keep this low usage threshold.

4.2 Product

After stating the user requirements, the product requirements also need to be stated. This can be done with the help of the MoSCoW method. This method helps with prioritizing requirements based on four criteria: “Must Have” (Mo), “Should Have” (S), “Could Have” (Co) and “Won’t have” (W) (Achimugu, Selamat, Ibrahim, & Mahrin, 2014). These are defined as the following. “Must Have” requirements are not negotiable. When these requirements are not delivered the whole project would fail. “Should Have” requirements are nice to have if at all possible. “Could Have” requirements that are nice to have if at all possible but slightly less beneficial. “Won’t Have” requirements can be seen as a “wish list”. These requirements are not unnecessary or unimportant but will not be implemented in the first final product.

4.2.1 Product requirements

The table below presents all requirements according to the MoSCoW prioritizing model. The requirements will be labeled as either a functional and non-functional requirement. They will be number for easier referencing later on.

Table 2: Functional and non-functional product requirements

Functional requirements	
FR1	The product **must** promote cycling
FR2	The product **should** be engaging
FR3	The digital product **should** be able to work on smartphones
FR4	The product **should** be a combination of a physical and a digital product
FR5	The physical product **should** be part of the landscape surrounding the bicycle lane
FR6	The product **should** be persuasive
FR7	The product **could** be able to protect the users’ privacy.

Non-functional requirements	
NFR1	The product **must** not be distracting
NFR2	The product **must** be easily accessible
NFR3	The product **should** increase commuting by bike
NFR4	The product **should** be affordable
NFR5	The product **could** add extra value to the users' life

4.3 Stakeholders

A stakeholder analysis is important for a design process because stakeholders help with creating the requirements. It is therefore important to have a clear overview of the stakeholder involved with the project, who they are, what they do and how they relate to each other.

4.3.1 Stakeholder identification

All stakeholders of this project will be identified and categorized using the Sharp et al (1999) method. They state that there are four different categories of stakeholders, users, developers, legislators and decision-makers.

Users are the people, groups or companies who will be using and interacting with the design, product or software directly. The developers are the people who develop the systems, the legislators are the professional bodies, government agencies, safety executives etc. They produce the guidelines of operation which influence and affect the design, product or project. They can either be local, national or international parties. The decision-makers are making decisions that relate to the development of the system, for example, managers and financial controllers in both the developers and users organization.

Table 3: *Stakeholder role identification*

Stakeholder	Role
Cyclists	User
CreaTe program	Decision-makers
Juust	Developers, decision-makers
Designer	Developers
Terneuzen multiplicity	Legislators
Zeeland province	Legislators

The table above shows the different stakeholders and their roles. The cyclists in this project are going to be the users of the designed end product and are interested in its use, that is why their assigned role is ‘users’. The Creative Technology program was given the role of decision-maker because they require this project to be finished within a certain period, influencing the development of the project Juust is the client and therefore is both got the role of developers and decision-makers. After all, they help with forming this project and help with deciding which requirements are important. The designer is a developer because this project needs to be developed and in the end, the designer will produce a product. The Terneuzen multiplicity and the Zeeland province are assigned as legislators because they are the parties who regulate the laws and regulations applying to Juust, which indirectly influence this project.

4.3.2 Stakeholder analysis

After the identification of the stakeholders, an analysis of the stakeholders will be done to identify their impact on this project. This will be done with the help of the power/interest matrix (Johnson, Scholes, & Whittington, 2008). This matrix classifies the stakeholders concerning the power they hold and to what extent they show interest in supporting this project. The power/interest matrix can be seen in the figure below.

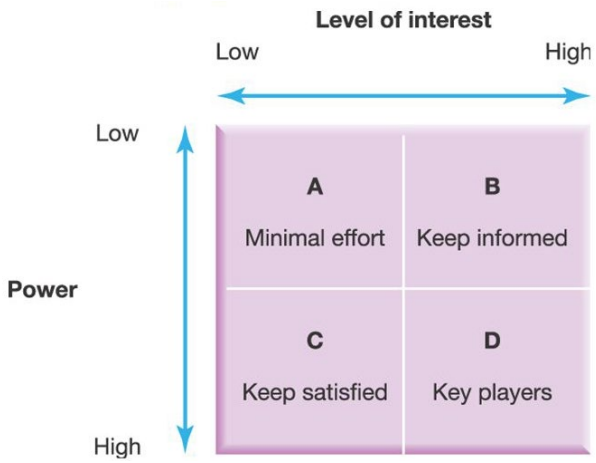

Figure 12: Power/interest matrix

Using this power/interest matrix proposed by Johnson et al (2008), the stakeholders of this project can be placed in this matrix. This is shown in the figure below.

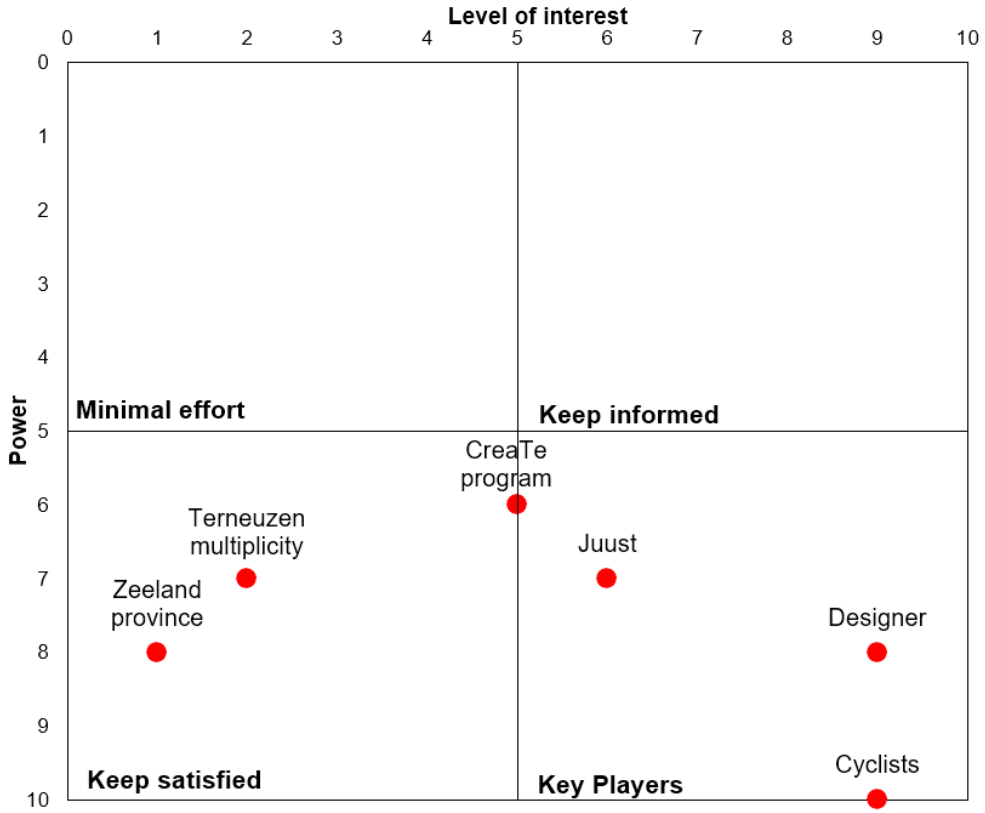

Figure 13: Stakeholder power/interest matrix

What can be seen in this matrix is that the cyclists have the most power and interest in this project. That is because they influence the requirements the most and they will benefit the most from the final prototype. The designer has as much interest in the project as the cyclists (users), but that it has less power. That is because the designer is tasked with designing a product that satisfies the users, forcing him to listen more to its potential users than listening to his requirements. Juust as the client has a lot of power, as almost much as the designer. Their interest however is lower because as a company this project is not their main concern and priority. The Creative Technology program has a moderate amount of power within this project because they have to be satisfied and happy with the results of this project. They have however not a high level of interest because it is the designer's project and duty to present a solution to the proposed problem. The province and multiplicity both have a low level of interest within this project. They both have a high power level on Juust and therefore they indirectly have the power within this project.

4.4 Concept generation

These conceptual ideas were established with the help of brainstorming, the state of the art and the previously written user, product and stakeholder analysis, four different concepts arose, all with different functionalities.

4.4.1 Concept functionality

Below, each concept with its functionality is described and a small example situation of the implementation of the concept will also be given.

1. **Functionality:** Recognition

   Implementation: A Bluetooth module to recognize cyclists

   Scenario: A cyclist is registered when cycling on to the bicycle highway because the Bluetooth on his/her smartphone is enabled. He/she is personally welcomed to the bicycle highway, making the cyclist feel recognized and one of a kind.

Figure 14: Concept 1 illustration

Figure 15: Ideation for LED-screen interface

Figure 16: Concept 1 illustration

2. **Functionality:** Recognition, digital gamification

   Implementation: Bluetooth or GPS recognizes cyclists and gives cyclists the option to use an app that keeps track of cycled kilometers, in exchange for real-life rewards

   Scenario: A man who lives in Terneuzen and works in Sluiskeel, often commutes by car. He does not see the added value of cycling to work. Until one day, his boss tells him that he can use the bicycle highway application to track his cycling commutes to save up for free lunches at the company or other rewards. This results in the man cycling to work more often, being more motivated and entertained.

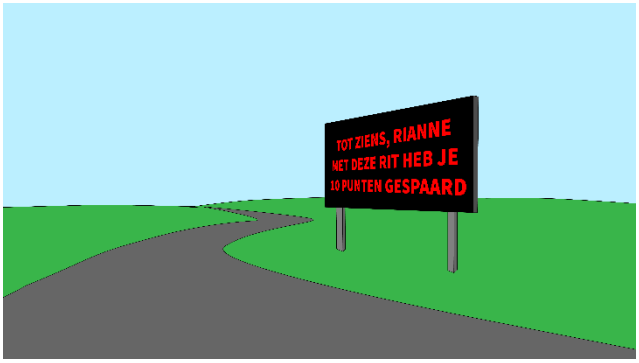

Figure 17: Concept 2 illustration

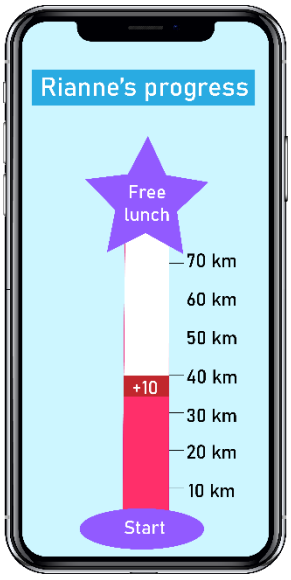

Figure 18: First prototype application concept 2

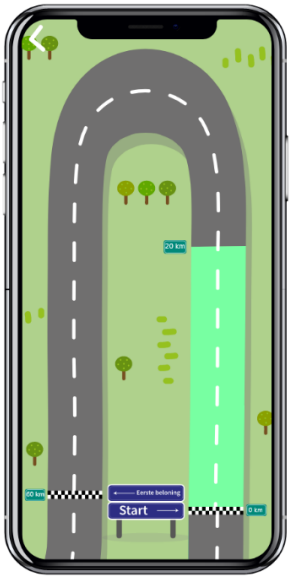

Figure 19: Second prototype application concept 2

3. **Functionality:** Recognition, digital gamification, physical gamification

   Implementation: Bluetooth or GPS recognizes cyclists and gives cyclists the option to use an app that keeps track of cycled kilometers, in exchange for real-life rewards. Multiple big physical LED-screen along the cycling path shows the cyclist's process and statistics.

   Scenario: A woman is cycling towards her work because she has heard about the reward system of the bicycle highway application because she is getting tired. Whilst cycling, she wonders how long it will take before she gets to her destination. An LED-screen at the side of the road displays her speed and estimated arrival time. This prevents the woman from looking at her phone during cycling. The next LED-screen displays a personal motivating text, lightening the woman her mood and motivates her to keep going.

Figure 21: Concept 3 illustration

Figure 20: Concept 3 illustration

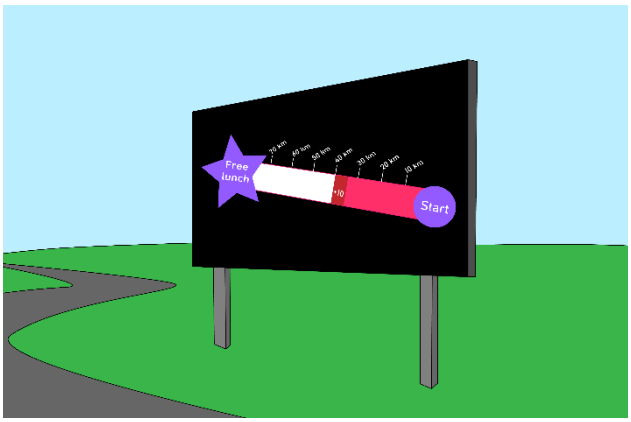

Figure 22: Concept 3 prototype physical gamification

4. **Functionality:** Recognition, digital gamification, physical gamification, providing context

   Implementation: Bluetooth or GPS recognizes cyclists and gives cyclists the option to use an app that keeps track of cycled kilometers, in exchange for real-life rewards. Multiple big physical LED-screens along the cycling path show the cyclist's process and statistics. Weather aspects such as wind or rain and other Zeeland related aspects allow cyclists to earn more rewards.

   Scenario: A schoolkid never looks forward to cycling to school and therefore often goes by bus, especially when it is raining or when there Is gale. However, he heard from his parents that he can earn rewards that he can use to get a discount in the toy store. They have also told him that when he decides to cycle with wind or rain, it will get him even more point and there is a possibility he can find a minigame along the way, which he can play on his phone. This causes the schoolkid to start cycling more because he is cycling for a certain reward.

Figure 23: Concept 4 illustration

For convenience, all the different concepts and their accompanying functionalities are once again summarized in the table below.

Table 4: Concept functionalities

		Functionalities			
Concept		Recognition	Digital gamification and interaction	Physical gamification and interaction	Providing context
	1	X			
	2	X	X		
	3	X	X	X	
	4	X	X	X	X

4.4.2 Risks and solutions

After establishing the different concepts and their accompanying functionalities and scenarios, it is important to describe the possible risks and the possible technical implementations of the concepts. In the table below, these risks and possible solutions are described.

Table 5: Concept risks and solutions

		Risks	Solutions
Concept	1	Concept 1 states that Bluetooth is used to make a connection between the cyclist and the LED-screen. However, this might not be the best technology for this concept, because it often takes two devices and some time to establish a connection. Because the cyclists cycle past the LED-board rather quickly, Bluetooth might not be able to establish a connection in this short time.	Something that might solve this problem is using RFID technology. RFID uses radio-technology to detect and identify objects with an RFID-tag. Those tags can quickly be identified, thus this technology will be able to quickly identify cyclists on the bicycle highway. Cyclists could carry the RFID-tag on their keychain or it can be mounted onto one of the bike wheels. Another solution might be using GPS to track whether a cyclist is close to the LED-board, thus register and greet him/her this way.
	2	Concept 2 states that users can make use of a mobile application to track his or her cycling progress. However, a phone application might not be the best solution for every user. For example, older or younger users. Both groups of potential users might not have (access to) mobile phones or do not understand it (yet).	To be able to also include these potential users, it is important to also offer a web browser application or an option to have multiple profiles within the application of one user. This way, no users will be excluded from the experience, hopefully encouraging more people to start cycling.
	3	Concept 3 states that the statistics and progress of the cyclist on the highway are displayed on the LED-screen. However, some cyclists might not like the fact that all their progress and cycle statistics are displayed so huge and openly, possibly feeling as if their privacy is invaded.	What might solve this problem is giving the users the option to either enable or disable this projecting option within the application. Here, they can decide what information they are comfortable with showing and what information they do not want to be displayed.
	4	Concept 4 states that the application will take the weather and other influences into account when generating bonus points for the users or that users can unlock minigames during their commute. However, these external motivators might not be triggering every user. Many users might still commute by car when it is pouring rain and adolescents and adults might not care about the minigames.	A solution that will tackle this problem is that users can earn bonus points for their cycling frequency, in addition to the weather and minigames motivators. More users might be more interested in earning bonuses by building up a so-called “cycle streak” or earning a “points doubler”.

4.5 Concept comparison

The two concepts that have the most potential are concept 2 and concept 4. They differ the most from each other, in terms that concept 2 only provides digital gamification where concept 4 also provides physical gamification. To see which one of the two concepts proves to be the most effective to promote cycling further research will be done in the following chapters.

5 Specification

In this chapter, the specification phase of the Creative Technology Design Process is described. The specifications of the final chosen concept will be described here, making it more specific and concrete. This will be done with the help of exploring several prototypes and short evaluations of the product requirements established in chapter 4.

5.1 Splitting up and specifying requirements

In subchapter 4.2.1, the general product requirements can be found. However, these requirements are both for the application and the LED-screen, combined into one table. These will now be split up to get a better overview of the individual requirements, making the realization of both easier in a later stage. There will also be a table containing requirements which only apply to the combination of the physical and digital product.

Table 6: Physical product requirements

	Functional requirements	**Motivation and specification**
FR5	The physical product **should** be part of the landscape surrounding the bicycle lane	The physical product will be located on one or more locations along the bicycle highway. This so that the earlier mentioned persuasion happens in a context where the promotion is needed.
FR6	The product **should** be persuasive	As mentioned earlier in chapter 2, State of the Art, persuasive technology includes different aspects, amongst others profiling and personalization. A holistic approach is needed to be able to persuade the user with the help of health, physical, mental, social aspects and social support. All these five elements are crucial in designing persuasive technology. That is why these five aspects need to be transferred to the user to persuade them into cycling more and this can be done by the LED board.
Non-functional requirements		
NFR1	The product **must** not be distracting	To prevent the physical product from being distracting, it should not display or play unexpected audio and music. This is potentially distracting for the users, neglecting the important safe commuting aspect of this project.

Table 7: Digital product requirements

Functional requirements		Motivation and specification
FR2	The product **should** be engaging	Both the physical and the digital prototype should be engaging for the promotion to have full its full impact. To keep the users engaged, the whole experience needs to be interactive and meaningful. Cyclists should feel excited to go cycling on “that cool interactive highway with the big LED-screen”.
FR3	The digital product **should** be able to work on smartphones	Often, gamification implementations come across the best in combination with an online application, mentioned in the State of the Art. Offering digital achievements and giving cyclists a sense of progress and competitiveness. These mechanisms have a persuasive influence on the cycling practice of the users, via the gamification.
Non-functional requirements		
NFR4	The product **should** be affordable, accessible and easy to understand	To keep the threshold low for users to start using the application, it is important that the product is low in costs or free, accessible and that it is easy to understand. When one of these requirements is not met, it will heavily influence the use of the product and therefore heavily influence the effectiveness of the promotion and therefore the increase of people commuting by bicycle.

Table 8: Combined product requirements

Functional requirements		Motivation and specification
FR1	The product **must** promote cycling	The physical product must promote cycling. This can be done by, for example, visualizing the impact of cycling such as the environmental, physical or health aspects. It the intension that showing the impact of a cycling commute within a physical environment has more impact on the (potential) users. The persuasion does not only happen on a phone or the computer screen, but it is also present in the actual environment of the cyclists. The application will enhance the promotion even more through the help of gamification, involving the users’ community and different gamification aspects such as rewards and keeping track of statistics.

FR4	The product **should** be a combination of a physical and a digital product	When combining the physical and digital gamification in the form of an online phone, what is to be expected is an engagement a persuasive effect, Is that it is twice as strong as when either one of the gamification aspects is used. Both enhance each other's strengths and that's why there should be a combination of a physical and digital product.
FR7	The product **could** be able to protect the users' privacy.	When displaying the users' names, personal progress or cycling statistics on a big LED-screen, the users might feel like their privacy is not valued or protected. To prevent this, it is an option to give the users the choice to either use a fake name/username or let them enable or disable certain privacy settings. This so that the users can decide what they want and what they do not want to show.
Non-functional requirements		
NFR5	The product **could** add extra value to the users' life	The goal of this project is to think of a solution that will promote cycling on bicycle highways in Zeeland. When this project succeeds, more people have decided to commute by bike more instead of taking the car. The fact that the product designed for this project contributes to people the choice to commute by bike, so making better, healthier and cheaper choices, states that the product adds value to the lives of people.

5.2 Final design

To be able to choose and improve the final concept, it is important that both concepts get evaluated. To help with deciding which concept to realize, a survey will be conducted. The respondents will be presented photos and phone mock-ups to base their decisions on. Respondents could pick their favorite type of gamification and their favorite concept. Because of recent COVID-19 developments currently happening in the world, it is not possible to conduct real-life research and to do user testing. That is why the testing and user testing will now be done in the following way. There is a big LED-screen on the university which is used to display messages and promotion posters. The mock-up interfaces of the product will be projected on this screen to create a "Wizard of Oz" effect. The respondents will also see a video of the application mockup in a video so that they can give their opinion and feedback afterwards. This feedback will then later be evaluated to produce a final design.

6 Realization

In this chapter, the realization phase of the Creative Technology Design process is described. All former established elements and specifications will be put together to form the final prototype. The methods and technologies that contribute to the final prototype will described. The final prosperities and design will be determined with the use of a survey, after which the final application and final interface designs for the LED-board will be designed.

6.1 Survey

To help with deciding whether the final idea will have the desired effect on the users and if it will answer the research question, a survey has been conducted. The respondents were asked to share their opinions about two proposed concept prototypes, both showed to them using a video.

6.1.1 Explanation videos

To give the respondents the best impression and understanding of the two prototypes, two videos were made. The first video was made to give the respondents an idea about how an application, used to track GPS data and earn real-life awards, would work and look. The application was made with the program Adobe XD. Afterwards, the prototype was recorded with the Windows Game Recording Tool. This was then used in the questionnaire.

Figure 24: Screenshot from the application clip

The second video was made to explain the second prototype to the respondents of the survey, as an addition to the given description of the prototype. The second concept is the concept with the addition of a physical LED-screen along the bicycle highway and RDIF recognition. The video was made the following way.

A big LED-screen is located at the beginning of the University of Twente terrain, standing along a cycling lane meant for students to cycle on. This LED-screen is used by the university to promote events and to spread the news about important dates or deadlines. A picture of the LED-screen can be seen below.

Figure 25: UTwente LED-screen

The man who manages the projections on this screen was contacted to ask whether it was possible to project different possible interfaces on this LED-screen. He said that it was possible, so the different interfaces were shown on the screen for an hour, which was then recorded and used to shoot clips which would later make a full video.

Afterwards, the shot clips were edited with the program Resolve. A Dutch voiceover was added to explain the prototype more in detail and how it should work. Next, English subtitles were added to give non-Dutch respondents the chance to understand the video as well. Finally, the final video was used in the questionnaire.

Figure 26: Screenshot from the video

6.1.2 Survey questions related to answering the research question

To be able to draw conclusions based on the held survey to answer the research questions, it is important to establish which questions mainly contribute to answering these. For convenience, the research questions are repeated below.

- *RQ:* How can the cycling experience on bicycle highways in Zeeland be improved with the help of engaging technologies to increase bicycle usage and promotion of cycling?
    - *Sub 1:* What types of technologies can be used persuasively and engagingly?
    - *Sub 2:* What factors influence cycling experiences and cycling frequency?
    - *Sub 3:* How can designing a technology contribute to encouraging and promoting cycling?

6.1.2.1 Block 1

In the first block of questions, the demographical details of the respondents are asked. This is to later get an overview of which results belong to which demographical groups. This research is currently focused on the bicycle highway to come in the Dutch province Zeeland, but getting the opinion from inhabitants of all different provinces will increase the validity of the research.

6.1.2.2 Block 2

The second block of questions focusses on the bicycle usage, specifically asking the respondents to pursue the questions and their living situation as if they were still living in the period pre-COVID-19. The corona crisis might have influenced the commuting behavior of people because of the current situation. But if everything goes well and the situation goes back to normal, the product still must remain relevant.

6.1.2.3 Block 3

The third block of questions starts with asking the respondents if they are familiar with the term bicycle highway since this research focusses on designing for such a specific cycling path (RQ). It then continues with the question if they prefer cycling on bicycle highways and why they do/do not. By asking this question, an insight is given into how people experience cycling on bicycle highways (sub 2). It continues by asking whether the respondents would be interested in an application that would keep track of the kilometers you have cycled on a bicycle highway in exchange for real-life rewards (sub 3).

6.1.2.4 Block 4

The fourth and last block asks the respondents to give their opinion about the two proposed prototypes. First, their opinion about the prototypes is asked. They have to state what they do and do not like about it. Then whether this prototype would increase their bicycle commuting behavior and why they think it would or would not. Because the prototypes make use of persuasive and engaging technologies, it directly leads back to the main research question. Certain factors and properties influence the respondents' opinions about whether the prototypes would contribute to increasing their bicycle behavior (RQ)(sub 2)(sub 3). Later, the respondents are specifically asked to share their opinion about the LED-screen addition. This gives insight into how such a physically persuasive and engaging technology would influence cycling behavior (RQ) (sub 1).

In the following sections, the results of the survey are further analyzed and discussed.

6.2 Final design

When designing the final prototypes, a look must be taken at the survey open questions regarding the personal prototype opinions of the respondents.

First, an interaction diagram is shown to get a better understanding of the final interaction between the user, the LED-board and the mobile application, an interaction diagram has been made to illustrate the interaction between the three main elements.

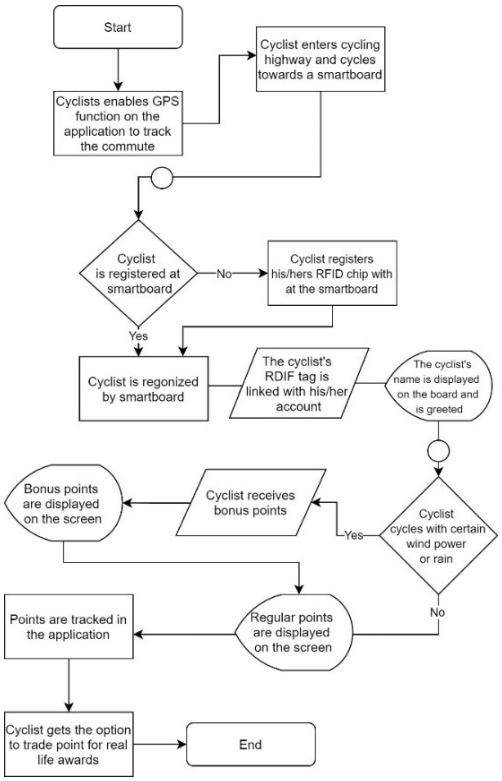

Figure 27: Interaction diagram

6.2.1 The first design of the application

Not a physically working, but a simulated concept app has been designed with the use of the tool Adobe XD. In figure 28, an overview of the first design of the application is shown. This design is based on the ideation chapter. This is also the version that was shown to the respondents in the survey. The application is in Dutch because most respondents of the survey were from the Netherlands. However, due to the icons and borrowed English words used in the Dutch language such as “dashboard” and “scoreboard”, non-Dutch respondents would still be able to understand the essence of the application.

Starting at the top left, the dashboard with the reward tile can be seen. This is the screen the users see when they open the app. It shows the users’ (nick)name, the level the user is currently is and a kilometer status bar. Below this, the users’ weekly progress can be seen. This displays how much kilometer the user has cycled during the week. On the bottom, the rewards tile can be seen. This tile takes the user to the rewards page. The rewards page can be seen in the bottom left.

Here, users can either use and view their owned rewards (which they have in their wallet) and they can browse other (still unowned) rewards in the redeem section. Here, they can buy rewards using their kilometers, acting as points.

Looking at the second upper left page, another dashboard layout with the scoreboard tile can be seen. The rest of the page is the same. Users can swipe between the rewards and the scoreboard tile. The scoreboard tile takes the users to the most right bottom page. The users can see their leaderboard with their friends/colleagues here.

The top middle page is the page where the users would register their cycling commute. They can start the GPS function by pressing the blue button, starting the registration. The GPS tracks how many kilometers the users' cycle, adding this to their kilometer score.

In the top-right, the settings page can be seen. It consists of all standard-settings an application should have, such as profile, notifications, password, privacy & security, help & support and about us.

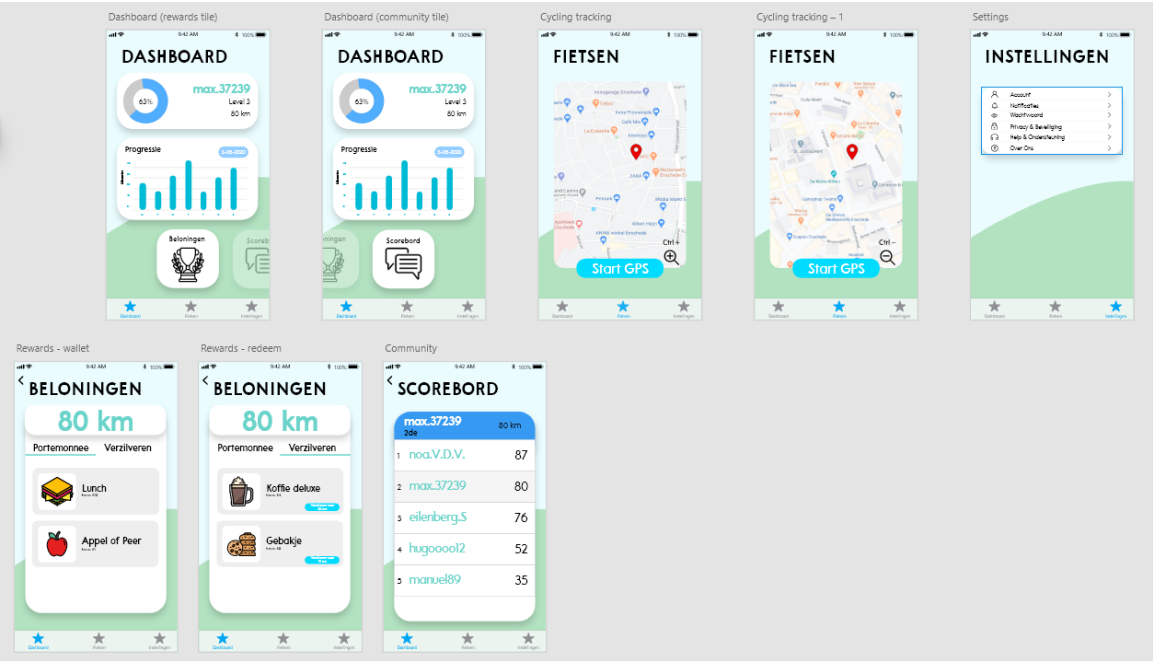

Figure 28: Initial application design overview

The survey was conducted so that improvements on the application of its design, interaction and user experience could be made, to maximize the experience and impact. The evaluation is described in the next section.

6.2.2 Evaluation of the application

The respondents were asked to share their opinion about the application prototype. First, they were presented with a 5 point Likert-scale, where they had to rate how likely it would be for them to use this prototype. For this, a Likert-scale was chosen because this way the respondent could make an easy decision to express his/her first impressions after seeing the video. In the figure below, the Likert-scale for the application can be seen.

Minimum	Maximum	Mean	Std Deviation	Variance	Count
0.00	5.00	3.21	1.40	1.95	156

Figure 29: Likert-scale application

What can be seen is that the mean of this sample is 3.21, with a standard deviation of 1.40. This is more than the average of 2.5 since the respondents had to give a number between 1 and 5. Meaning that the majority of the people would be likely to use the application.

Next, their opinion was asked by the use of open questions. Open-ended questions are great for getting genuine feedback, because they offer participants the chance to tell what they're experiencing, without limiting their answers by forcing them to choose standard answers.

In the table below, the evaluation results of the application are portrayed. All open answers were analyzed so that common themes and categories could be identified. Next, similar comments were divided into these sections to create a clear overview. These results illustrate a summary of the respondents' perceptions and opinions on the design.

Table 9: Application survey results

Topic	**Like**	**Add/improve/change**
Design	• Simple and clear layout • Nice colors and icons • Happy vibes	• More professional/adultlike appearance
Gamification elements	• Leaderboard • Awards • Saving up • Levels • Working towards a realistic and physical goal	• More competition elements • Saving up for charity instead of for personal use
Keeping track of statistics	• It keeps track of the cycled kilometers • Real-time information	• Being able to see where you cycled on the map to connect people
Usability	• Quick and easy to use	• Being able to connect with other apps • Using GPS tracking without opening the app

Interface	• Straightforward layout	• Fewer buttons to make it easier to navigate when you're tight on time • Clearing up what the difference is between the wallet and redeeming
Conveying of information	• Almost all information is visible at once • Awards overview	• Viewing stats of others (if they agree)

In the table above respondents already briefly suggest other engaging options for the application to have. Since it is the goal to make the app as engaging as possible, a question was asked about what other social interaction they would like to see in the application. An overview of these answers can be seen in the image below.

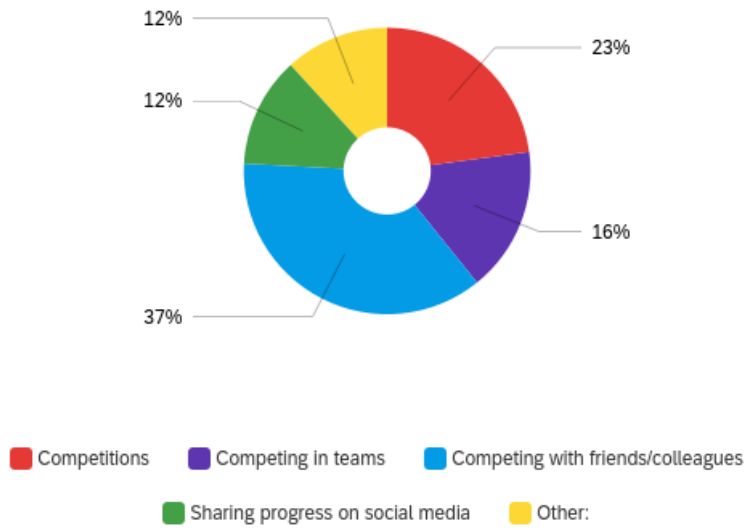

Figure 30: Social interaction preference

Other popular given answers were things such as being able to set personal goals, keeping track of personal records (cycling a certain route within a certain time) and being able to save points for others. What stands out is that adding prominent competition aspects is favored by more than 70% of the participants. Barratt (2017) stated that to motivate people to achieve their goals, competing against others is a huge part. That many people chose more competing aspects is therefore foreseeable. So to make the application more engaging and persuasive, more competition aspects need to be added.

One question asked reflects on both the application and the LED-screens, which is the question asking the respondents to state other aspects they would like to see added to this project (either added to the application or the LED-screen). The responses can be found in the image below.

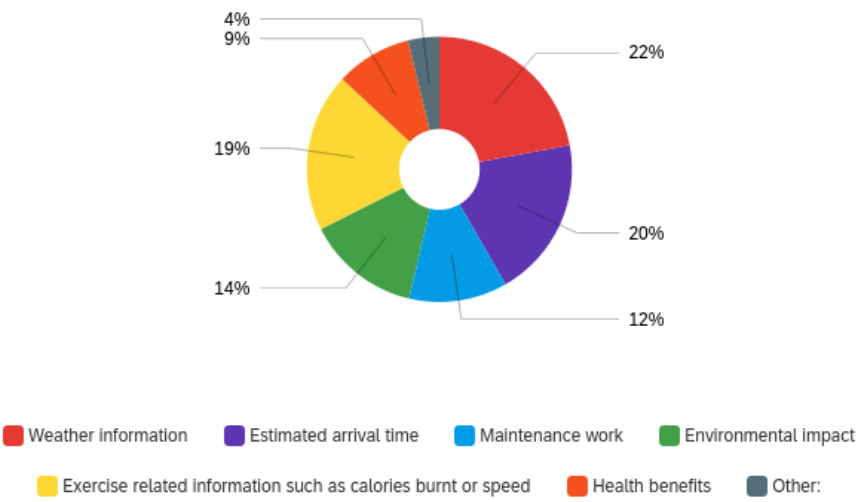

Figure 31: Other possible implementations

What can be seen is that all options are almost equal. Health benefits are rated the lowest, this might be caused by the fact that many respondents stated that they already use other fitness and exercise equipment and applications to keep track of their fitness level.

6.2.3 The final design (realization) of the application

When applying all the feedback giving by analyzing the questions of the survey, a final design of the application can be made. When implementing the feedback, it can be assumed that the number of people saying that the application would increase their bicycle behavior would also increase. Not a physically working, but a simulated concept app has been designed with the use of the tool Adobe XD. The app is called “BiHi”, short for bicycle highway. The final design of the application can be seen in the image(s) below.

Starting with the image below, a screenshot of the first two pages of the application can be seen. Here, new users can sign up if they do not have an account or users can log in if they already had an account. Users also have the option to sign up or log in using either a social media platform such as Facebook, Instagram or Strava. One thing that was mentioned was the possibility to connect with other platforms, which was implemented in this final design.

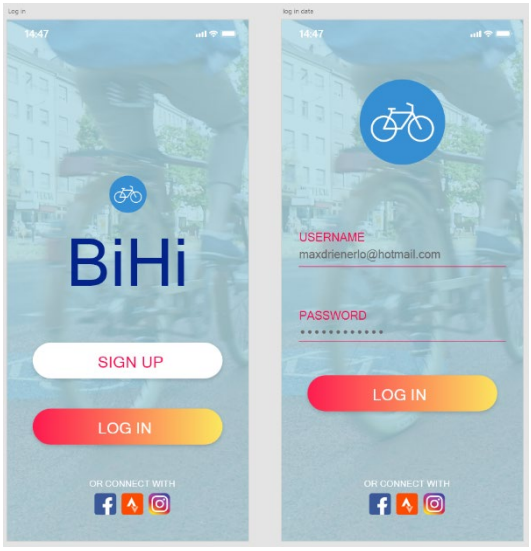

Figure 32: Log in

Once logged in or signed up, the app goes to the cycling page where the user can start registration straight away. This page is seen in the top left corner. The map shows the location of the user and allows the user to start the registration.

Once the registration is started, the app goes to the goes to the cycling registration page, the second upper page. Here the bicycle commute is registered in kilometers and calories. The user can pause the session by clicking on the pause button, where he or she can continue or stop the session, seen in the third upper page. If the user stops the session after a short time, the app will ask whether the user wants to save or delete the session. If the session is stopped after a longer period, the session will be saved automatically.

Once the user chooses to stop and save the session, he/she is taken to the fourth upper page, where the cycling history can be seen, as well as statistics of the past rides. The user can choose to delete or share sessions.

The fifth upper page displays the friends map, where users of the application can see where their friends are. This way they can send a notification to one of their to notify them they want to cycle together of just to let their friends know they are about to go cycling, adding to the competing element, seen in the lowermost right page.

Here, the user also has the option to enable or disable ghost mode, meaning their location will not be shown on the map of their friends. Users also can manage other privacy settings here, such as things the app offers they do or do not want to see projected on the LED-screens alongside the bicycle highway, guaranteeing the privacy of the users.

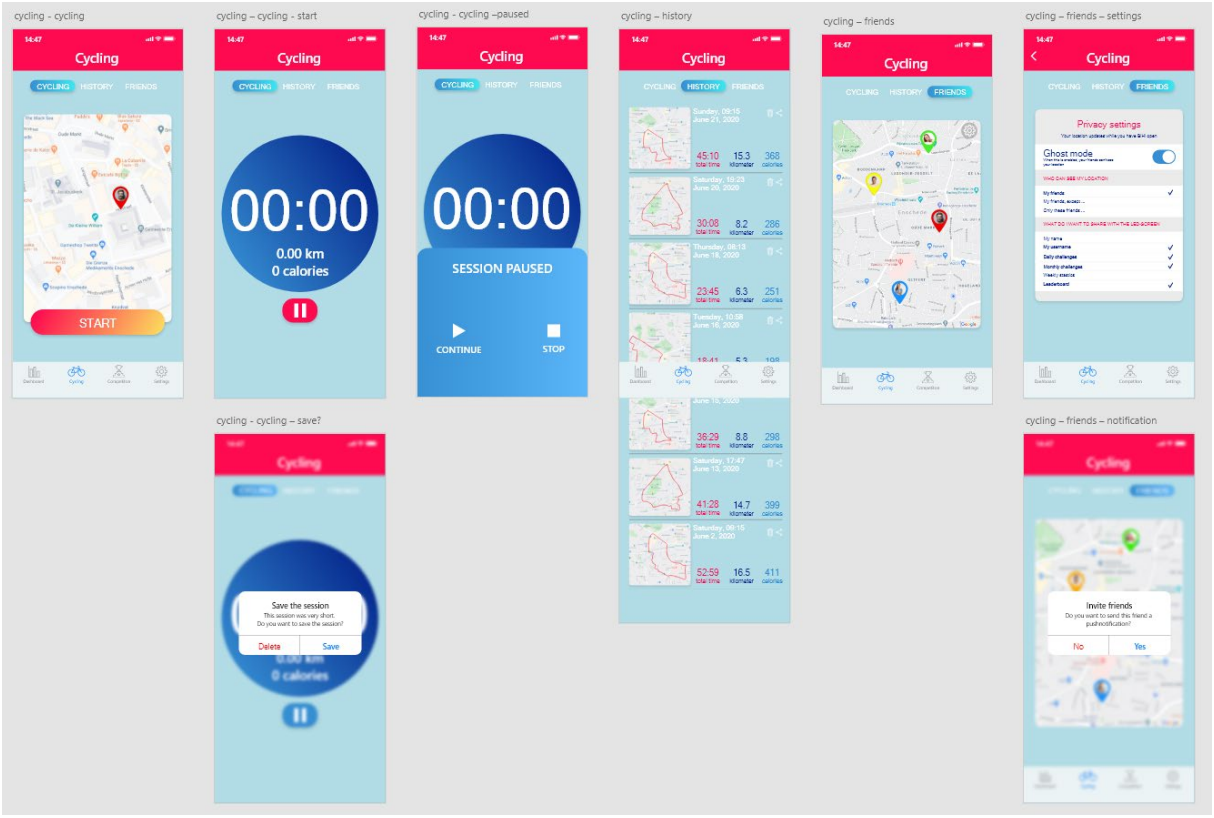

Figure 33: Cycling pages

The next image shows an overview of the dashboard pages. The two left pages display the weekly summary of the users' cycling activity, showing the weekly activity, total distance cycles, totally burned calories and total active time of that day. Here, the total cycled kilometers can be seen, as well as the days where the users have been active which are marked with a blue circle.

The two right pages display the owned and available rewards the users can save up for. On the “my rewards” page users can see the rewards they already own and can use. “View offers” allows the users to browse rewards they do not yet own. Here they can also redeem these offers by using their kilometers, now acting as points. However, the kilometers which are traded for rewards do not affect the users’ total cycled kilometers. Once the user would cycle five kilometers, both the cycled kilometers and kilometer points would go up by 5.

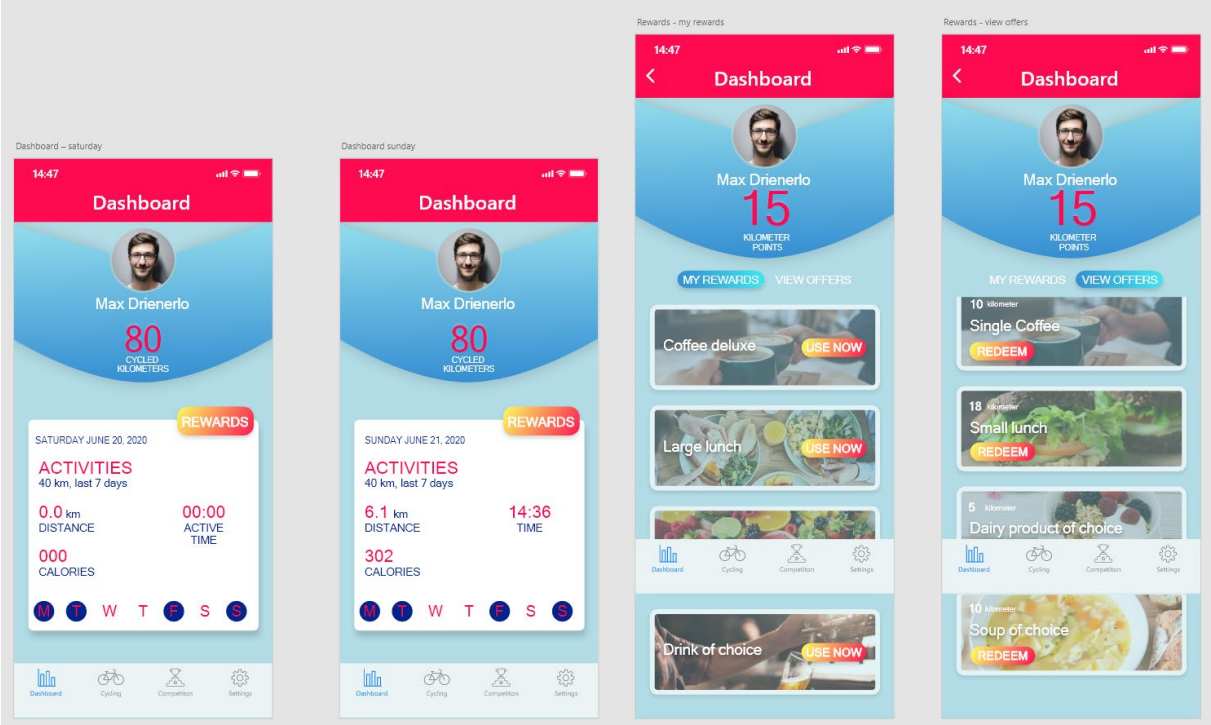

Figure 34: Dashboard pages

The next image shows the competition page of the app. What can be seen here is the leaderboard of friends, the teams where the user is part of, the weekly and monthly challenges. The most left page displays the personal leaderboard, containing all the friends of the user raked on who has the most cycled kilometers. In this design, Max has the highest score with 80 km, also marked with the number 1 in gold at the end of his name. The user is also able to search for friends who are also registered on BiHi.

Next is the team overview. This page displays all the teams that the user is a member of. The user can search within his teams or find new ones to join. Being part of a team and having a name in a leaderboard should add to the users’ feeling of healthy social pressure, making him or her more motivated to stay high in the ranks, thus cycling more.

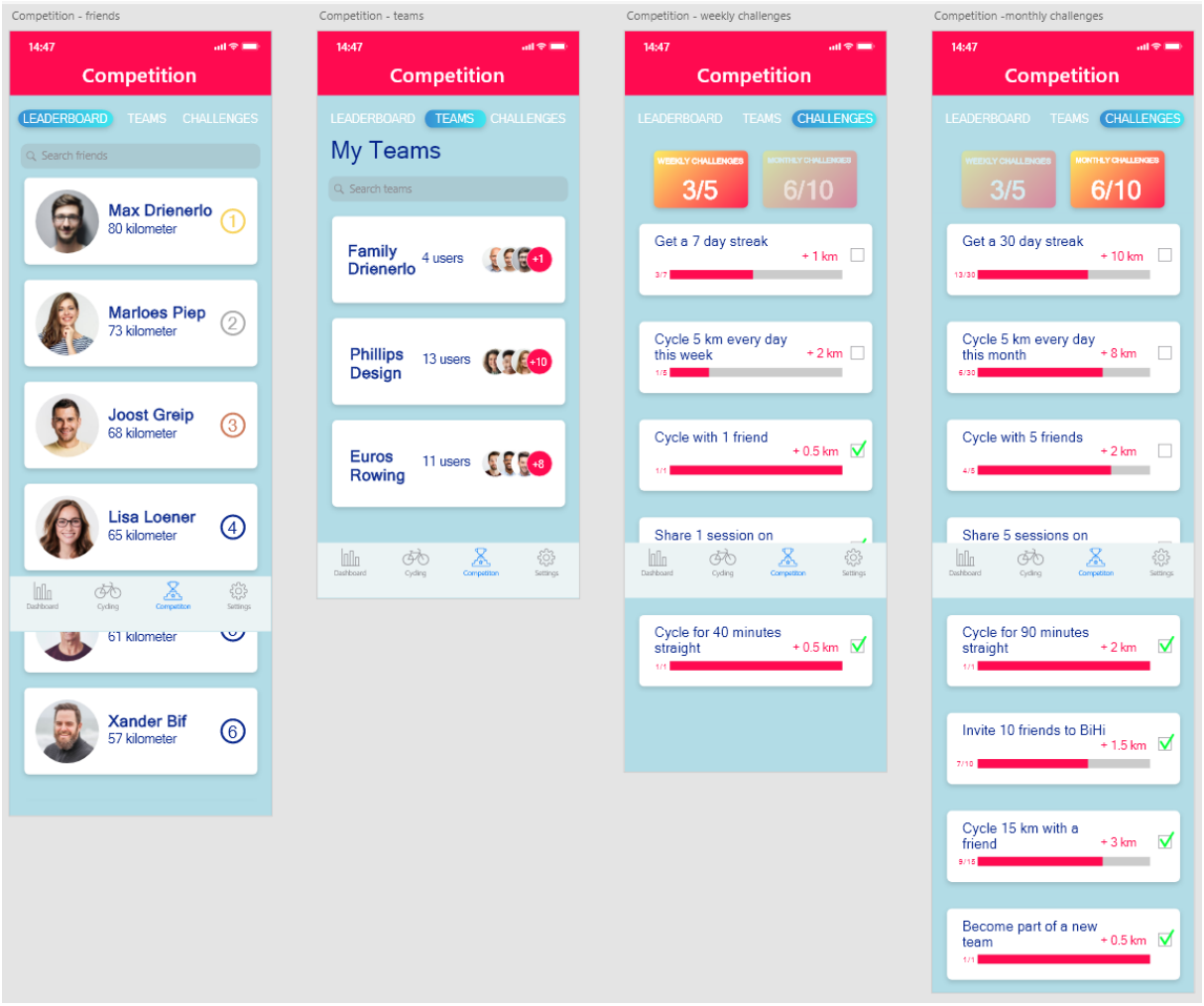

Figure 35: Competition pages

The two right pages present the weekly and monthly challenges which the user can complete in return for additional kilometers. As the name suggests, the weekly challenges reset weekly and the monthly challenges reset every month. These challenges should act as an external drive for the users to interact more with the application, as well as motivate them to cycle more. As mentioned by Barratt (2017), quests enforce users to stay engaged and interested in their exercise and encourages them to choose cycling over going by car.

6.2.4 Initial design LED-screen

In figure 29, an overview of the initial four LED-screen interfaces can be seen. These were also shown in the video presented in the survey. These four interfaces display the most engaging and persuasive aspects to stimulate bicycle usage and were designed based on the ideation chapter. The top-left interface shows the users' leaderboard, where the uses' box itself is enlarged to differentiate from the other on the scoreboard. The leaderboard on the LED-screen matches with the leaderboard of the application. The top-right interface shows the screen a user would see when he/she cycles during rain, with heavy wind or other weather defies. The user gets a bonus whilst cycling during one or more of these conditions. The bottom left displays the cycle streak a user has. Each successive day the user cycles on the bicycle highway, the streak number goes up by one. The bottom right interface displays a personal welcome message for the user. He/she is greeted when cycling past a LED-screen.

Figure 36: Initial design of LED-screen interfaces overview

6.2.5 Evaluation of the LED-screen

The respondents were asked to share their opinion about the LED-screen prototype. As with the app, respondents were presented with a 5 point Likert-scale, where they had to rate how likely it would be for them to use this prototype. In the figure below, the Likert-scale for the application can be seen.

Minimum	Maximum	Mean	Std Deviation	Variance	Count
0.00	5.00	2.65	1.40	1.97	156

Figure 37: Likert-scale LED-screen

What can be seen is that the mean of this sample is 2.65, with a standard deviation of 1.40. This is more than the average of 2.5 since the respondents had to give a number between 1 and 5. Meaning that the majority of the people would be likely to use the application. However, this number is only slightly above the average of 2.5. A possibility for the big difference between this number and the application mean of 3.21 is that the respondents did not understand the video correctly. It is also possible that the proposed idea is not as known as an application, thus the respondents not seeing its potential value.

Next, their opinion was asked by the use of open questions. In the table below, the evaluation results of the application are portrayed. All open answers were analyzed so that common themes and categories could be identified. Next, similar comments were divided into these sections to create a clear overview. These results illustrate a summary of the respondents' perceptions and opinions on the design.

Table 10: LED-screen survey results

Topic	**Like**	**Add/improve/change**
Design	• Clear • Fun • Playful	• More subtle and adultlike design • Variate in designs • Being able to personalize the screen projections
Gamification	• Extra point for weather defies • Competition with friends through the leaderboard • Stimulates people in real life to save up for the rewards	• Motivation should come from the persons within and not from the outside • Possible demotivating for people with lesser fitness • Raking of teams
Interaction	• Personal recognition and attention • Encouragement • Dynamic	• Can be distracting
Visibility	• Users can flex with their scores	• Valuable information such as names and scores on a public board might have privacy issues • Visibility of personal information when multiple people are cycling past the screen
Conveying of information	• Real-life information • Insight into personal performances • Personal feedback	• Corporate consolidation • News items
Keeping track of statistics	• Tracking without the app	• More valuable statistics

In the table above respondents already briefly suggest other engaging implementations for the LED-screens to have. Since it is the goal to make the LED-screens as engaging as possible, a question was asked about whether according to the respondents. This being whether the LED-screens have added value to the project. This was asked because when the LED-screens appeared to be redundant, there would be no purpose of continuing and physically realizing them.

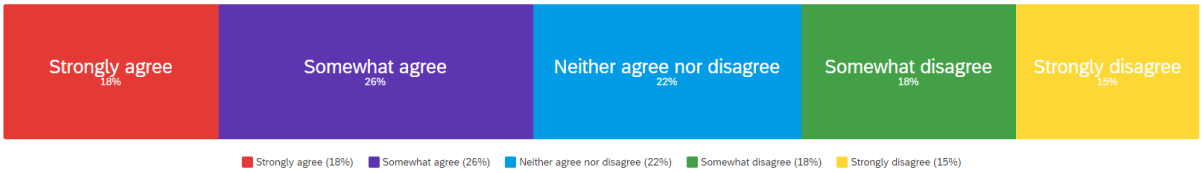

Figure 38: Added value LED-screen

What can be noted when looking at this data is that 44% of the people think the LED-screens have added value to the project, whereas only 33% disagree with this statement. This gives a positive indication that if the LED-screens would be physically realized, they would be an added value to the application.

After is, an open-ended question was proposed, asking people to state exactly why they choose if the LED-screens either would or would not increase their bicycle commute behavior. A list of some of the most outstanding answers can be seen down below. The given Dutch answers are translates for convenience.

Table 11: Valuable answers to the question about LED-screen relevance

1) "*You will see the screen every day and therefore be in contact with the app every day. Instead of forgetting the prototype (the app) after a week and not using it anymore.*"
2) "*It connects digital life with real life.*"
3) *"Publicly shown information may deter people."*
4) *"I think extrinsic stimuli only work in the short term. I think it's more in the quality of the bicycle connection."*
5) *"It's a safe way to see information during cycling so that you don't have to look at your phone"*
6) *"I don't want to use this because of privacy issues."*

Responses 1, 2 and 5 all transfer meaningful and insightful information about the core ideas regarding this project. Responses 3, 4 and 6 all raise important issues that need to be taken into account seriously and if possible need to be avoided.

6.2.6 The final design (realization) of the LED-screen

When applying all the feedback giving by analyzing the questions of the survey, a final design of the LED-screens interface can be made. When implementing the feedback, it can be assumed that the number of people saying that the application would increase their bicycle behavior would also increase. The final design of the LED-screens can be seen in the images below.

Figure 39: LED-screen interfaces

What can be seen here is that more variations are added to the initial design, giving the experience more variation and a surprise element, keeping the user engaged and curious about what could be on the next projections. The four initial designs resued in the final design and these interfaces were the greeting projection, the bonus, the leaderboard and the streak. Like mentioned in the realization of the application, the user now can enable or

disable the projection of his or her name and choose what projections are and are not allowed to be projected in public. This guarantees the users' privacy and therefore could make them more positive about making use of the LED-screens. The same goes for enabling or disabling the option to project leaderboards or cycled kilometers, which could shame users and even demotivate them to cycle.

Feedback from the survey was to make the design more adultlike and less distracting. The first design had a lot of colors and a more playful design, whereas the final design is more subtle but carrying across the same messages.

The first image displays the welcoming message that the users see on the first LED-screen that they encounter. It welcomes the users on the bicycle highway, making them feel recognized and seen.

The next projection is one that projects the users' weekly achievements. Here it shows three challenges that the user completed that week. This gives the user a clear sense of progress and achievement, making him or her more motivated to keep on completing challenges. This also goes for the fourth image, displaying the users' cycling activity of the day before, stimulating both the user and other cyclists on the bicycle highway.

Next is the streak projection, projecting the cycling streak. This is connected to showing the user progress in their habit-breaking activity. Hristova, Dumit, Lieberoth, & Slunecko (2019, p.2) state that:

"Once a streak has been established, a series of well-known psychological processes including social reciprocity and loss aversion is likely to increase its cognitive and emotional salience."

Meaning that the streak and maintain the streak will become important to the user, thus resulting in the users' bicycle usage.

The fifth image displays weather information, withholding users from looking at and using their phone during cycling. Weather information was also mentioned in the survey as one of the things people would like to see on the LED-screens.

The sixth and seventh displays are were both also part of the first design, because they both convey gamification aspects contributing to the motivating and persuading of the user. The sixth interface shows the personal leaderboard of the user, provided that the user enabled this display. Projecting this leaderboard information in real-time to engage and encourage the user. The bonus will be given to users when it is raining, snowing or other weather defies to motivate users despite the weather.

7 Evaluation

In this chapter, the evaluation, the general evaluation of the two prototypes will be described. As opposed to chapter 6, where a specific evaluation of the two prototypes was described. This general evaluation will describe whether the two proposed prototypes have the potential to stimulate and motivate potential users to increase their cycling behavior.

7.1 Method

This survey was conducted in the period between 10/06/2020 and 19/06/2020 and can be found in appendix 10.1. The respondents were presented a survey with several general demographical questions, followed by questions regarding their knowledge about a bicycle highway and questions about the proposed prototypes.

7.1.1 Participants

During this research, 156 respondents filled in the survey, this amount of responses will be considered as sufficient to recognize them as representative. The survey was available in Dutch and English, so either Dutch people or non-Dutch people who speak English were able to respond. The sampling method to gather responses was through personal connections, such as friends and family by the use of WhatsApp. The survey was also posted on several Social Media platforms such as Facebook and LinkedIn, resulting in respondents who were not friends nor family. All participants were asked to agree with an online consent form, where they agreed that their answers would be used in this report. The gender distribution comes down to a distribution where 54% was female, 45% was male and 1% did not specify. Their ages were ranging from 18 -74. There were no respondents in the category 75-84 or 84+. The respondents came from all municipalities in the Netherlands, expect from Limburg and Zeeland. This will be further devised in the limitations.

7.1.2 Materials

For the evaluation, one survey was designed using Qualtrics. The survey consisted of 27 questions and took roughly 10 minutes to fill in. All different kinds of questions were used to get the best insight, such as multiple choice with either single or multiple answers possibilities, open questions and Likert scale questions.

7.2 Results

In the following sections, the general evaluation will be described. The three categories questions will be analyzed and discussed in are bicycle behavior and bicycle highways, cycling stimulants, and improvements and engagement of cycling behavior.

7.2.1 Bicycle behavior and bicycle highways

To understand and get a better insight into current cycling behavior and experiences on bicycle highways, respondents were asked to answer for what activity they mostly commuted for. This can be seen in image 35 below.

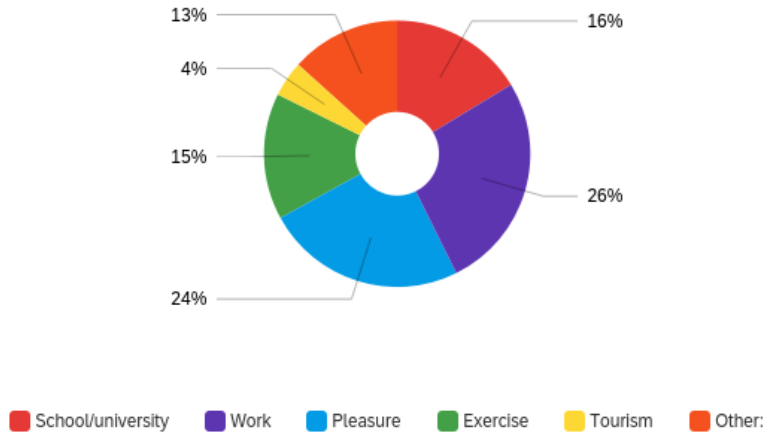

Figure 40: Commuting behavior

What stands out is that the answers are rather evenly distributed. The two main categories are work and pleasure.

Next, to understand and get a better insight into current cycling experiences on bicycle highways and whether these are preferred, respondents were asked if they preferred cycling on bicycle highways and elaborate on their opinion. Both people who knew and who didn't know what a bicycle highway was, was able to respond because the definition, as well as two images, were given before this question. Municipalities need to gain access to the current knowledge of their inhabitants so that the benefits can be promoted better.

Figure 41: Bicycle highway opinion

What can be seen is that the majority of the people prefer cycling on bicycle highways, as opposed to cycling on normal bicycle paths. This outcome could be expected because the highways are made for easy and convenient commuting. When looking at the reasoning behind the given answers, six main themes can be recognized. These are:

- Bicycle highways are saver than regular cycling paths and are very convenient.
- Cycling on a bicycle highway can be done undisturbedly and without traffic disruption.
- They are well-maintained
- Bicycle highways tend to be boring because it's mostly one straight road.
- They're not very inviting for recreational cycling.
- For some people, it's not on the route and they wouldn't detour for this.

The designed prototypes in this project hopefully contribute to improving the mentioned malfunctions of bicycle highways. It is to be expected that the LED screens will make the cycle paths less boring. When cycling on the highways would have added value, some people might start detouring for this, knowing they can save up for rewards.

7.2.2 Cycling stimulants

To understand whether the real-life awards offered by the application and the real-life stimulants offered by the LED-screen would have an actual impact and if they actually would be used, two questions were asked regarding this inquiry. The two images below give insight into real-life awards and real-life stimulants increase bicycle commuting behavior according to the respondents.

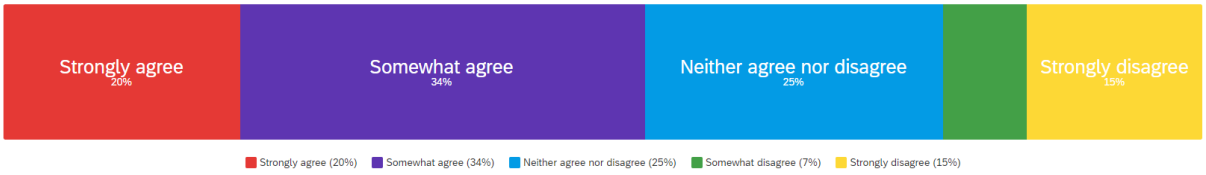

Figure 42: Real-life awards

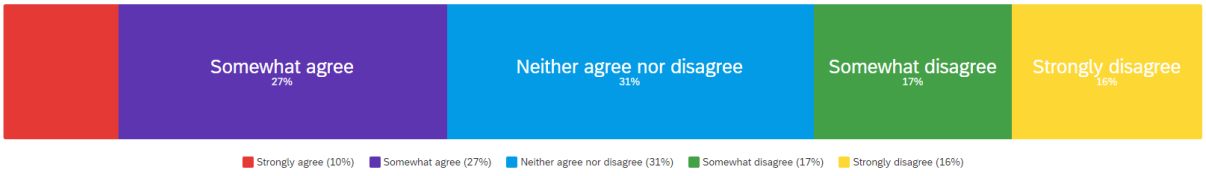

Figure 43: Real-life stimulants

When looking at and comparing these two images, what instantly stands out is that more people believe that real-life awards would increase their bicycle commuting behavior, as opposed to real-life stimulants. This difference could be caused by the fact that people do not find a digital encouragement of a LED-screen counterbalance the real-life award they would otherwise get when using the application.

Another possibility for the difference in these results can be that, already written in de evaluation of the design of the LED-screen 6.2.5, many respondents had issues with the lack of privacy the LED-screens might have. This can also be seen in the results to the question of whether the personalization of the LED-screens would increase bicycle commuting behavior, seen in figure 39.

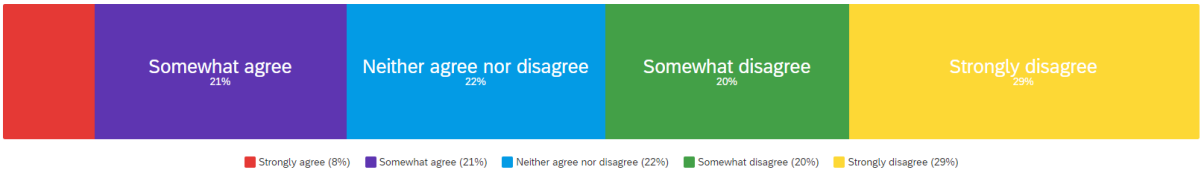

Figure 44: Personalization of LED-screens

It seems that the majority of the people do not agree with the fact that the personalization of the LED-screens would Increase their commuting behavior. This due to many responses to the possible privacy issues. Not everyone liked the fact that their name and matching scores are hugely displayed in public. A possible solution to this problem which is also explained in the final realization of the LED-screen is to give users the option whether they want to either use a pseudo name/username, if they want to display their scores of if they want neither of them, eliminating these interfaces for them and not showing them during their commute.

7.2.3 Improvement and engagement of cycling behavior

Finally, the question was asked whether the proposed prototypes would increase the respondents their bicycle commute behavior (and when applicable, if it would decrease their car commuting behavior). First, a look is taken at the results of the application.

Figure 45: Increasing bicycle behavior application

When looking at this image, 42% percent of the people stated that the application would increase their bicycle behavior.

They were also asked to specify their choice, and the common themes from people who agree with the fact that it stimulates bicycle behavior say that is it motivating, fun and that competitiveness stimulates. What can be concluded from these answers is that it can play a role in stimulating people into cycling more, especially if they need that little bit extra stimulation.

Next, a look is taken a the results of the LED-screens.

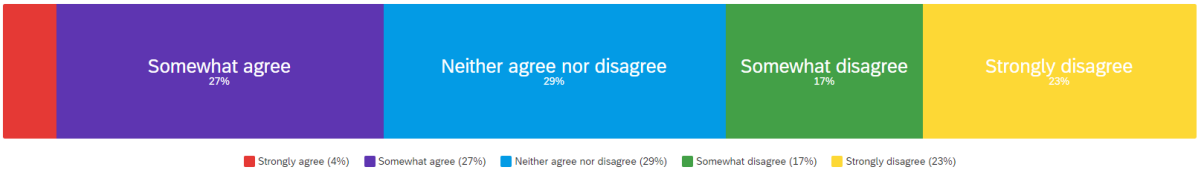

Figure 46: Increasing bicycle behavior LED-screens

When looking at this image, only 31% percent of the people stated that the application would increase their bicycle behavior, as opposed to 40% stating that it would not affect their bicycle behavior. What can be concluded from these answers is that these issues probably again relates to the earlier mention malfunctions of the prototype such as privacy issues and displayed points that could decrease cycling behavior. On the other hand, people state that they like competing and fun aspects, so options to increase especially this should be further explored.

8 Conclusion, discussion and recommendations

In this chapter, the conclusion will be drawn and an answer to the research questions will be given. Furthermore, a discussion will be held to analyzed unexpected outcomes and highlights. Lastly, recommendations for future work will be given.

8.1 Conclusion

To answer the research question, the goal of this project will be repeated. After this, the research question will be repeated and answered, followed by an overall conclusion.

The goal of this graduation project was to design a prototype that would improve cycling experiences on bicycle highways in Zeeland with the help of engaging technologies to increase bicycle usage and promotion of cycling. Knowledge was gained about engaging and persuasive design, gamification and cycling promotion, to get more insight into finding a possible solution. Gamification was used as a tool and was implemented in both prototypes, to design a motivational mobile application as well as to design motivational and encouraging LED-screen interfaces. Literature research has shown many effective ways to physically stimulate people. However, most of them were either only done in the digital or physical domain. The goal of this research was to combine digital and physical gamification, to get the best results possible. A mobile application and LED-screen interfaces were designed and realized in the form of a prototype, which then both were tested utilizing a survey. The results were positive, thus the question could be answered.

To recap, the main research question was: *How can cycling experience on bicycle highways in Zeeland be improved with the help of engaging technologies to increase bicycle usage and promotion of cycling?* With the sub-questions:

- *Sub 1:* What types of technologies can be used persuasively and engagingly?
- *Sub 2:* What factors influence cycling experiences and cycling frequency?
- *Sub 3:* How can designing a technology contribute to encouraging and promoting cycling?

To answer the main research question, first, the sub-questions need to be answered. The first sub-question asks what types of technologies can be used persuasively and engagingly. As described in chapter 2.2, persuasive technologies are not specific technologies, but rather strategies to make standard technologies more attractive and persuasive. These strategies include simulated experiences, surveillance (monitoring and tracking), virtual groups, personalization and environments of discovery. These elements were then translated to this project to achieve this persuasive element. To make the design engaging, it needs to have a holistic approach, meaning that there needs to be a wide spectrum of health like physical, mental and social aspects.

The second sub-question asks what factors influence cycling experiences and cycling frequency. These factors are the social, sensory and spatial phenomenon, where for this project interaction, weather and identification are the three most important aspects.

The third sub-question asks how designing a technology can contribute to, encouraging and promoting cycling. This can be done by looking at the standard framework when researching transportation, which focuses on travel time as the cost of moving from origin to destination, classified by the five most important “D-variables”. This being density, diversity, distance to

transit, destination accessibility and design. When applying these elements to persuasive technology design, users will be motivated to cycle and the smart solution can be used to promote cycling, by emphasizing how entertaining the solution is, making potential users curious.

The final solution that answers the main research question is: cycling experiences on bicycle highways in Zeeland can be improved by designing a digital mobile application and a physical LED-screen, together with offering real-life rewards that, when combined, engage and motivate users to increase bicycle usage and promote cycling. The application and the LED-screens motivate the users in such a way that they become or stay motivated to commute in a more sustainable conscious way and contributing to the car to bicycle shift.

Altogether, it can be concluded that the combination of the mobile app and the LED-screen can serve as a valuable engaging and stimulating force that contributes to the increasement of people's bicycle commuting behavior.

8.2 Discussion

Although this research provides insightful information on how bicycle commutes can be stimulated, some critical remarks can be made. The first main remark is that the newly designed mobile application and LED-screen interfaces should be user tested a second time to properly validate their value after the re-design. The second remark that can be made is that right now, it is assumed that the newly designed LED-screen interface combined with the privacy settings changes in the app will enhance cycling behavior whereas the first design did not. The main issue with using the LED-screen appears to be privacy-related, so it is acceptable to assume that once the feedback was implemented, this issue would resolve. However, there is not any proof for this yet and other malfunctions might occur, therefore the importance of second and maybe third-time user testing will be essential.

The last remark that can be made is that there have been zero responses from inhabitants of the province Zeeland, even though the initial proposal was specifically targeted towards the bicycle highway that would get built there. Though, conclusions still can be drawn from the results, because the cycling behavior does not vary much between provinces in the Netherlands. Added to this is that there does not yet exist a bicycle highway in Zeeland, as opposed to other provinces such as Overijssel, Friesland, Brabant and Gelderland. There were enough respondents from those provinces, therefore valuable information about bicycle highways and prototype opinions was collected, providing enough information so that the proposed design would also be appropriate for Zeeland.

8.3 Further recommendations

When looking at this project, several recommendations can be made based on the results and the discussion. The first recommendation is that the more testing, the better. As mentioned in the discussion, newer versions of the design and technology must be tested several times to get the optimal result. Instead of only online testing or set-up user tests, real-life tests could be done. Participants would be able to access the fully working mobile application and physical LED-screens can be placed along a bicycle highway. This then needs to be programmed and finalized, being another recommendation. The participants will then be asked to use and evaluate the application and LED-screen interaction in real-time, experiencing the engagement and encouragement first handed. This would provide real-life results, giving even more valuable insight.

Another recommendation is that more research needs to be done on how to make the application and the LED-screen interfaces and interaction possibilities even more convincing and how to implement more encouraging and engaging gamification aspects. By doing this, the two designs will become more persuasive, resulting in a big shift from car commutes to more bicycle commutes.

It will also be important that companies who want to collaborate with the project are found, to not only stimulate regular bicycle behavior but also specifically work-related commutes. This ensures that employees as well shift from car to bike (if the distance allows it). This will also automatically stimulate competition between colleges, enhancing the competing aspects of the design even more.

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10 Appendices

10.1 Survey

Graduation Project: Improving cycling experiences on bicycle highways

Information Brochure Survey

'Improving cycling experiences on bicycle highways'

Bachelor Thesis Creative Technology 2020

Rianne Ouderkerken s1968556

Contact: r.f.ouderkerken@student.utwente.nl

This bachelor thesis research project focuses on how cycling experiences on bicycle highways can be improved in order to promote and therefore increase commutes done by bicycles. This includes everyone commuting for either work or school/university. Research has shown that people can be motivated to commute by non-motorized transportation modes such as cycling and walking by using external motivators and with the implementation of gamification. This research aims to create a product that can promote commuting by bicycle and that can motivate users to increase their bicycle commute frequency. This research consists of an online survey with multiple choice and open questions of around 10 minutes, with the aim of getting an insight into the transportation behavior and opinion about the designed product. There are no risks of participating. The possible benefit of participating is that people become aware, through the survey, that commuting by non-motorized transportation modes can be beneficial in their daily lives. Participation is completely voluntary, and the participant can quit whenever they feel the need to. The data is anonymous and will not be shared with anyone outside of the research team. Participants will be asked to fill in their age and gender but not their name or any personal contact details, thus no personally identifiable data will be collected. It will only be used as an informative method of understanding the problem and the target audience.

☐ I hereby declare that I have been informed in a manner which is clear to me about the nature and method of the research as described in the aforementioned

information brochure ‘Improving cycling experiences on bicycle highways. My questions have been answered to my satisfaction. (1)

☐ I agree of my own free will to participate in this research and I reserve the right to withdraw this consent without the need to give any reason and I am aware that I may withdraw from the experiment at any time. (2)

☐ I agree to the publications of my research results if done so anonymously. (3)

If I request further information about the research, now or in the future, I may contact Rianne Ouderkerken at r.f.ouderkerken@student.utwente.nl.

If you have any complaints about this research, please direct them to the secretary of the Ethics Committee of the Faculty of Electrical Engineering, Mathematics and Computer Science at the University of Twente, P.O. Box 217, 7500 AE Enschede (NL), email: ethics-comm-ewi@utwente.nl).

Q1 On the top of the screen, a progress bar can be seen

Q12 What is your gender?

○ Male (1)

○ Female (2)

○ Prefer not to say (3)

Q3 What is your age?

- 18 - 24 (1)
- 25 - 34 (2)
- 35 - 44 (3)
- 45 - 54 (4)
- 55 - 64 (5)
- 65 - 74 (6)
- 75 - 84 (7)
- 85 or older (8)

Q4 In which municipality do you currently live?

- Noord-Holland (1)
- Zuid-Holland (2)
- Zeeland (3)
- Noord-Brabant (4)
- Utrecht (5)
- Flevoland (6)
- Friesland (7)
- Groningen (8)
- Drenthe (9)
- Overijssel (10)
- Gelderland (11)
- Limburg (12)

Q5 For the following questions, it is important to consider your living situation before the COVID-19 crisis and pursue these questions as if you are living in the period pre-corona.

Q6 Before COVID-19, How many times per week did you cycle on average?

- ○ Daily (1)
- ○ 4-6 times a week (2)
- ○ 2-3 times a week (3)
- ○ Once a week (4)
- ○ Never (5)

Q7 Before COVID-19, you mainly commuted for

- ☐ School/university (1)
- ☐ Work (2)
- ☐ Pleasure (3)
- ☐ Exercise (4)
- ☐ Tourism (5)
- ☐ Other: (6) _____

As mentioned in the title, this research focuses on improving cycling experiences and bicycle commutes on bicycle highways in the Netherlands. The next questions will be about these specific highways.

Bicycle highways are wide cycle paths with mostly gentle curves, so you can overtake safely and hardly lose any speed doing so. You encounter as few traffic lights and intersections as

possible. If there are any intersections, cyclists usually have right of way, meaning you can cycle undisturbed to work or school or during a day of recreational cycling. (ANWB, 2019). Below two pictures of bicycle highways can be seen.

Q8 Before I read the definition of a bicycle highway above, I already was familiar with the term "bicycle highway" (fietssnelweg)

- Yes (1)
- Maybe (2)
- No (3)

Q9 I prefer cycling on bicycle highways than I do on regular highways

- Strongly agree (1)
- Somewhat agree (2)
- Neither agree nor disagree (3)
- Somewhat disagree (4)
- Strongly disagree (5)

Q10 Please explain or describe your choice (why do/don't you prefer bicycle highways?)

Q11 If there would exist an application which would keep track of the kilometers you have cycled on a bicycle highway in exchange for real life rewards (such as a free sandwich from the canteen at university/work), would you be interested in using this?

- ○ Definitely yes (1)
- ○ Probably yes (2)
- ○ Neutral (3)
- ○ Probably not (4)
- ○ Definitely not (5)

Q12
Please explain or describe your choice (why would/wouldn't you be interested?)

_____

Q26 Next, two possible prototypes will be shown. Please share your opinion and answer the questions truthfully.

The first possible prototype for this project is as follows. Users of the bicycle highway can register their commute on a mobile phone application. With the help of GPS, the application keeps track of their cycled kilometers and allows the users to save up these kilometers to earn virtual awards, which they then later can trade for real life awards. A video of the application can be seen below.

Q22 On a scale from 1-5, how likely are you to use this application? (1 means extremely unlikely, 5 means extremely likely)

1 2 3 4 5

Q24 In your own words, what are the things you like the most about this prototype?

_____

Q29 In your own words, what would you improve/change/add about this prototype?

_____

Q35 What kind of social interaction would you like to see in the app?

- ☐ Competitions (1)
- ☐ Competing in teams (2)
- ☐ Competing with friends/colleagues (4)
- ☐ Sharing progress on social media (6)
- ☐ Other: (7) _____
- ☐ None of the above (8)

Q38 Real life awards would increase my motivation to commute by bike.

- ○ Strongly agree (1)
- ○ Somewhat agree (2)
- ○ Neither agree nor disagree (3)
- ○ Somewhat disagree (4)
- ○ Strongly disagree (5)

Q25 This prototype would increase my bicycle commute behavior (and when applicable: decrease my car commute behavior)

- ○ Strongly agree (1)
- ○ Somewhat agree (2)
- ○ Neither agree nor disagree (3)
- ○ Somewhat disagree (4)
- ○ Strongly disagree (5)

Q45 Please explain or describe your choice (why would/wouldn't it increase your bicycle commute behavior?)

_____

Q33 The second proposed prototype build on the previous prototype. Users of the bicycle highway can register their commute on a mobile phone application. With the help of GPS, the application keeps track of their cycled kilometers and allows the users to save up these kilometers to earn virtual awards, which they then later can trade for real life awards. Added to this prototype is a LED-screen, which greets the registered user's on the bicycle highway. It projects the users' rank within their personal leader boards, gives bonuses for weather defies and keeps track of streaks. This all is done with RFID technology whenever a users passes on of these LED-screens. These LED-screens are supposed to enhance the motivating aspects of the application, therefore hopefully amplifying bicycle commutes and bicycle highway usage. The prototype can be seen and is explained in the video below.

Q32 On a scale from 1-5, how likely are you to use this application? (1 means extremely unlikely, 5 means extremely likely)

1 2 3 4 5

Q34 In your own words, what are the things you like the most about this prototype?

_____

Q35 In your own words, what would you improve/change/add about this prototype?

_____

Q36
This prototype would increase my bicycle commute behavior (and when applicable: decrease my car commute behavior)

- ○ Strongly agree (1)
- ○ Somewhat agree (2)
- ○ Neither agree nor disagree (3)
- ○ Somewhat disagree (4)
- ○ Strongly disagree (5)

Q46 Please explain or describe your choice (why would/wouldn't it increase your bicycle commute behavior?)

_____

Q39 The personalization of the LED-screen would increase my motivation to commute by bike.

- Strongly agree (1)
- Somewhat agree (2)
- Neither agree nor disagree (3)
- Somewhat disagree (4)
- Strongly disagree (5)

Q41 Real life stimulants would increase my motivation to commute by bike.

- Strongly agree (1)
- Somewhat agree (2)
- Neither agree nor disagree (3)
- Somewhat disagree (4)
- Strongly disagree (5)

Q37 What might be other aspects you would like to see added to this project? (either added to the application or to the LED-screen)

- [ ] Weather information (4)
- [ ] Estimated arrival time (6)
- [ ] Maintenance work (7)
- [ ] Environmental impact (8)
- [ ] Exercise related information such as calories burnt or speed (9)
- [ ] Health benefits (10)
- [ ] Other: (11) _____
- [ ] None of the above (12)

Q37 I think that this personalized LED-screen has added value to the application prototype

- ○ Strongly agree (1)
- ○ Somewhat agree (2)
- ○ Neither agree nor disagree (3)
- ○ Somewhat disagree (4)
- ○ Strongly disagree (5)

Q47 Please explain or describe your choice (why do you think it does/doesn't have added value?)

_____\