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# **GAMIFICATION AS A TOOL TO PROMOTE SUSTAINABLE TRANSPORT MODES**

Introduction to gamification for professionals  
among the field of transport

Master's thesis  
Faculty of Built Environment  
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# ABSTRACT

Jussi Sjögren: Gamification as a tool to promote sustainable transport modes  
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This thesis examines how gamification could be used in various kinds of transport interventions and measures to enable a modal shift towards more sustainable transport system. Goal of the thesis is to function as an introduction to gamification for professionals working in the transport sector. Value of this thesis arise from the new possibilities gamification provides for transport sector to enhance existing and new measures and interventions to achieve the goal of more sustainable transport system.

The first research questions of this thesis set the aim to find linkages between gamification and transport. With the second research question the aim was to form a framework for professionals in the transport sector to ease the design or evaluation process of transport measures and interventions that use gamification. After forming a framework, and assessing it with five case studies, the third research question examined what these case studies taught about gamification in the field of transport.

This thesis consists of a literature review which had a goal to form the framework, and of an evaluation of five case studies where the previously formed framework is used with real world examples. The literature review was a thematic analysis which was based on the themes found with the chosen definition of gamification which was "a process of enhancing a service with affordances for gameful experiences in order to support user's overall value creation". This definition was broken into key areas, which were used as the steps of the framework.

Key areas that were found in the literature review are easy to understand, and thus enables the reader to easily approach the framework. Found key areas could also be valuable information as standalone data points to explain gamefulness in the transport system.

The framework was found to be a helpful and easy to use tool to examine gamification among transport sector's solutions. It may lack in its depth of analysis and detail, which is acceptable considering the introductory nature of the framework, which fulfils goals of this thesis.

Case studies presented different transport related solutions and situations, which were analysed for their gamefulness. Main findings with case studies were about the usage of the framework, and how gamification can be used in the transport context.

Limitations were recognised with both literature review and case studies. Literature review was limited with the methodology choice of thematic analysis compared to a broader perspective that a thorough systematic review could have provided. Limitations with case studies were with the depth of analysis that was conducted. A more in-depth analysis could have provided more information and perspectives about examined case studies, but this approach was chosen to fit the aims and goals of the thesis. These limitations could be examined in the future research.

Keywords: gamification, transport system, framework, design process, evaluation process, gameful elements, enhancing services, promotion measures, sustainable transport

The originality of this thesis has been checked using the Turnitin OriginalityCheck service.

# TIIVISTELMÄ

Jussi Sjögren: Pelillistäminen kestävien liikennemuotojen edistämisen työkaluna  
Diplomityö  
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Diplomityössä tutkittiin kuinka pelillistämistä voidaan hyödyntää liikennejärjestelmiin vaikuttavissa toimenpiteissä, joilla mahdollistetaan kulkutapajakaumassa muutoksia, jotka kehittävät liikennejärjestelmiä kestävämmiksi. Diplomityön tavoitteena oli toimia johdantona pelillistämiseen liikennealan ammattilaisille. Diplomityön arvo perustuu uusiin mahdollisuuksiin, jotka liikenteeseen liittyvien toimenpiteiden parantaminen pelillistämällä luo.

Ensimmäinen tutkimuskysymys tarkasteli pelillistämisen ja liikenteen välisiä yhteyksiä. Toisen tutkimuskysymyksen tavoitteena oli rakentaa kehys helpottamaan pelillistämistä käyttävien toimenpiteiden suunnittelua ja arviointia. Kehyksen kehittämisen jälkeen sitä hyödynnettiin viiden case-kohteen arvioimiseksi, ja kolmas tutkimuskysymys tutki mitä case-kohteiden avulla pystytään oppimaan pelillistämisestä liikennealalla.

Diplomityö koostuu kirjallisuuskatsauksesta, jonka tavoitteena oli luoda kehys, sekä viiden case-kohteen arvioinnista, jossa aiemmin luotua kehystä käytettiin tosimaailman esimerkeillä. Kirjallisuuskatsaus oli teemallinen katsaus, joka perustui diplomityössä käytettäväksi valittuun pelillistämisen määritelmään. Valittu määritelmä oli ”prosessi, jolla parannetaan palvelua tukemaan käyttäjän arvonmuodostamista mahdollistamalla pelillisiä kokemuksia”. Tämä määritelmä eroteltiin avaintekijöihin, jotka muodostivat kehyyksen osiot.

Kirjallisuuskatsauksessa tunnistetut avaintekijät ovat helposti ymmärrettäviä, joten kehys on lukijalle helposti lähestyttävä. Tunnistetut avaintekijät voivat toimia myös itsenäisesti arvokkaana informaationa liikennejärjestelmän pelillistämisestä.

Kehys todettiin hyödylliseksi ja helppokäyttöiseksi tavaksi tutkia pelillistämistä liikennesektorin ratkaisussa. Kehys ei suoranaisesti tarjoa erityisen syvää analyysia, mikä on hyväksyttävää ottaen huomioon kehyyksen johdannollisen luonteen, joka täyttää tämän diplomityön tavoitteet.

Case-kohteet esittelivät erilaisia liikenteeseen liittyviä ratkaisuja ja tilanteita, joiden pelillisyyttä arvioitiin. Tärkeimmät havainnot case-kohteiden arvioinnista liittyivät kehyyksen käyttöön ja pelillistämisen hyödyntämiseen liikennekontekstissa.

Kirjallisuuskatsauksessa ja case-kohteiden tutkimuksessa tunnistettiin rajoituksia. Kirjallisuuskatsauksen teemallinen analyysi oli tietoinen metodivalinta, mutta laaja systemaattinen katsaus olisi voinut syventää kirjallisuuskatsauksen näkökulmaa ja tuottaa syvällisempiä tuloksia. Case kohteiden arvioinnissa olisi voinut käyttää metodeja, jotka olisivat tuottaneet syvällisempiä tuloksia, kuten haastatteluja ja projektien tuloksien syvällisempää analysointia. Nämä rajoitukset toimivat myös ehdotuksina aiheen jatkotutkimuksille.

Avainsanat: pelillistäminen, liikennejärjestelmä, suunnittelukehys, suunnitteluprosessi, arviointiprosessi, pelilliset elementit, palvelun kehittäminen, edistämistoimenpiteet, kestävä liikenne

Tämän julkaisun alkuperäisyys on tarkastettu Turnitin OriginalityCheck –ohjelmalla.

## PREFACE

While working as a project designer on the promotion program for walking and cycling for the city of Hämeenlinna, during the research phase I came across a promotion program for another Finnish city as a reference, and they had stated inclusion of gamification as one of their secondary goals. This amused me a lot as I looked down on the idea, but after a while amusement turned into reflection of my prejudice. I could not stop thinking about this idea, and when it was time to decide the topic for my thesis I wanted to find out if there is something behind the idea. This thesis process was long and delayed, but after all the struggles I will happily end the Teekkari phase of my life.

This thesis saw the light of the day thanks to the encouragement to pursue the topic that I received from the original examiners DSc Roni Utriainen and DSc Steve O'Hern, as well as the trust and belief in the project and me that my final examiners Professor Heikki Liimatainen and MSc Hanne Tiikkaja had. Thank you, and sorry for your patience. Also, I would like to show my appreciation for MSc Riku Viri for producing couple of the figures used in this thesis with the humble salary of two chocolate bars.

During my years of studying, I had the pleasure of attending inspiring courses to learn more about transport and built environment. I would especially like to thank MSc Jouni Sivenius, MSc Markus Pöllänen, and Professor Heikki Liimatainen for this inspiration. DSc Steve O'Hern, I would like to thank for mentoring and guiding me to become a better researcher in the early steps of my academic career. Thank you for letting me fail and learn from it, I will cherish your lessons for the rest of my career.

I am also very appreciative of all of the knowledge I have gathered from the countless colleagues I have met in the coffee tables of Tampere University, Pöyry, Hämeenlinnan kaupunki, and Tampereen Infra. Also, thank you friends and fellows for all of the memories (and Finnish Championship) made during these study years. The countless days and nights I've spent with you have made me the person I am today. After all, none of this could have happened without my bedrock Tiina, and our darling cats. Kiitos.

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Jussi Sjögren

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# 1. INTRODUCTION

## 1.1 Background

### 1.1.1 Sustainable transport

There are many reasons to increase sustainable transport habits. Sustainable transport is a broad umbrella term that covers a lot of different transport modes limited only by the varying definitions of sustainability. Sustainability can easily be seen only as a goal to minimize greenhouse gasses (GHG), but I see that it is important to consider the wider picture and factor in the social and economic views on a global scale. World Commission on Economic Development (1987) stated that “humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs”. Considering this statement, it is important to understand the short- and long-term effects that transport systems and their modal splits produce.

In addition to the environmental perspective, sustainable transport should include the social and economic concerns of society that can be described as equity as well. Sustainability can be criticised as a term because it is broad and indefinite, and it can be adopted to different meanings (Litman and Burwell, 2006). Thus, it might be hard to pinpoint the meaning, but creating a more sustainable society in an environmental, economic, and social sense through enhanced transport planning has an intrinsic value.

This thesis limits the usage of the terms sustainable transport to include public transport, walking, cycling, and micromobility comparable to cycling (even if the environmental sustainability of some micromobility modes can be questioned (e.g., Hollingsworth et al. (2019))). The term active mobility in this thesis includes walking, cycling, and micromobility comparable to cycling.

The health benefits of active transport come from the regular physical activity. Also, it should be noted that a commuter who uses public transport will presumably be more physically active during the commute compared to a person travelling with a personal car, because of the journey to the public transport stop.

In a study, Oja et al. (1998) found that physical activity of sufficient duration, expanded by commuting to work by walking and cycling, improves the cardiorespiratory and metabolic fitness of previously sedentary adults. Based on their observations, Oja et al. (1998) concluded that it is plausible to recommend commuting to work by walking and cycling as an effective and widely applicable means of health-enhancing physical activity.

Some concerns have been raised about road safety and exposure to pollution for pedestrians and cyclists. Concern about pollution exposure is unfounded when compared to the benefits of physical activity, but pollution exposure should be reduced as far as possible (Rabl and de Nazelle, 2012). With modal split changes that replace combustion engine vehicles with active mobility, it can be assumed that the air and noise pollution decrease in the affected area.

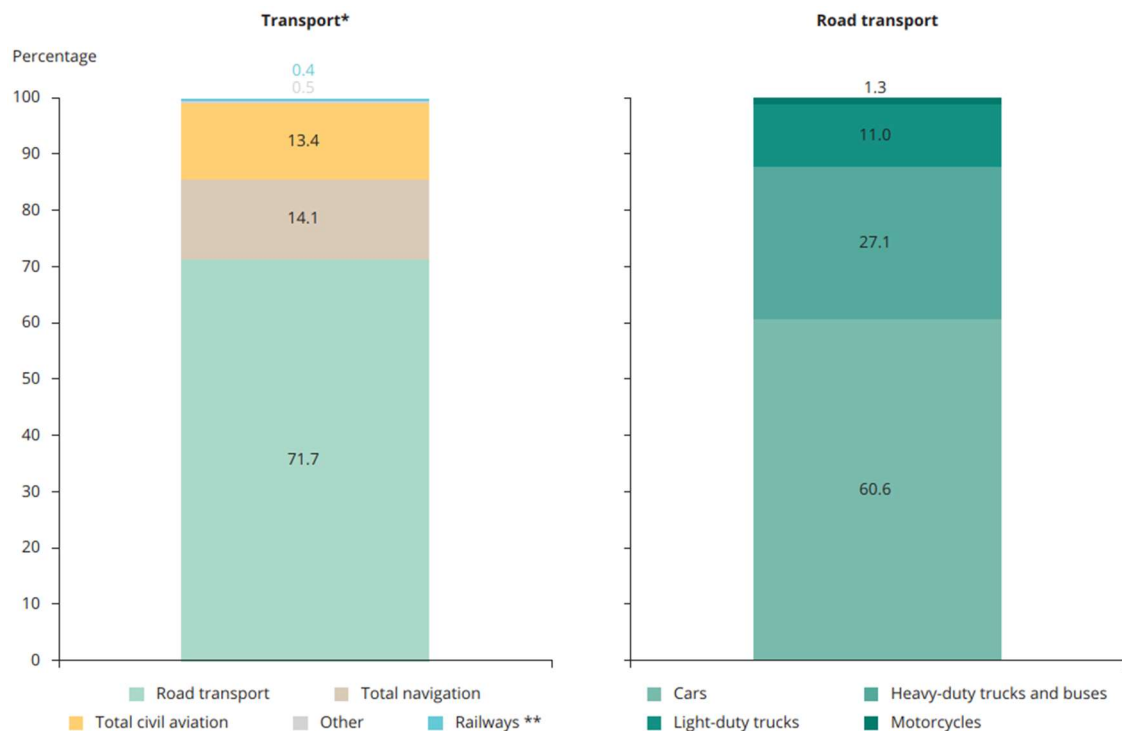
Road safety is important, especially in the transitional stages of transport systems. It is important to understand that cars are involved and often responsible for a large proportion of accidents where a pedestrian or cyclist is killed or seriously injured (Klanjčić et al., 2022). A motorist is less likely to collide with a pedestrian or a cyclist when there are a lot of pedestrians and cyclists, and thus policies that promote active mobility appear to be effective in improving the safety of pedestrians and cyclists (Jacobsen, 2003).

Active transport is a great tool to hold on to a regularly active lifestyle for an ageing population. For the ageing population, higher physical activity level is associated with a smaller decline in mobility performance and a better disease risk profile which may lower the risk for future diseases and subsequent decline in functional status (Visser et al., 2002). After giving up driving, the mobility of the ageing population may suffer, which hurts the essential utilitarian and basic needs, but also the quality of life needs like independence, social networks, exercising cognitive skills, and performing non-essential activities (Musselwhite and Haddad, 2010). For those who cannot drive a car anymore, it is essential to provide easy access to services and amenities with a transport mode that is suitable for the user, in combination with developing road infrastructure that is in line with characteristics, travel needs, and capabilities of a diverse set of road users (O'Hern and Oxley, 2015).

All health benefits that sustainable transport offers that enhance the quality of life are in my perspective valuable. In addition to this, there are economic benefits of improved health (Rabl and de Nazelle, 2012). In an economic sense, investments in walking and cycling infrastructure tend to have good cost-benefit ratios. One example of this could be the Sælensminde (2004) study about the cost-benefit analysis of walking and cycling investments in three different Norwegian cities which found net benefit/cost ratios from

2.94 to 14.34 weighing a lot on the reduced costs related to severe diseases and ailments. In 2007 the health economic assessment tool (HEAT) was developed from an original idea of Harry Rutter (World Health Organization, 2017). HEAT is a model that can be used as an effective and user-friendly tool to help with incorporating the health impacts of cycling into a transport appraisal and have a major impact on cost-benefit ratios that provide economic incentives for investments for better walking and cycling solutions (Rutter et al., 2013).

European Environment Agency (2022) report “Decarbonising road transport: the role of vehicles, fuels and transport demand” analyses the driving factors underlying the trend in greenhouse gas emissions from road transport in the EU. Figure 1 shows that cars are responsible for over 40 % of the transport GHG emissions in the EU. Because of this, it is important to reduce the GHG emissions from cars. The report recognizes the potential of modal shift by shifting to the least GHG-emitting transport modes and non-motorised modes, like the sustainable modes that this thesis is concerned about.



**Figure 1.** Road transport emissions as a share of EU transport GHG emissions and share of road transport emissions by mode in the EU-27, 2019 (European Environment Agency, 2022)

To promote sustainable transport and achieve advantages such as the earlier mentioned, the most common tools are policy changes and different kinds of programs, that

lead to measures affecting the transport systems (Banister, 2008). These measures can be as an example regulation (changing laws or creating economic incentives), investments (improving infrastructure, offering more affordable transport options, or enabling other measures), events (educating and exciting people about wanted change interactively), or communication (informing, educating, and exciting people) (Banister, 2008; Loukopoulos, 2007).

A way to classify different promoting measures is to divide them into hard and soft measures (Bamberg et al., 2011). Hard measures can be as an example improvements in infrastructure, monetary measures, or rationing use of vehicle type on certain areas or streets. These measures are often the most prominent for the regular citizen, but their effectiveness alone is not certain, and they might face public or political opposition. Soft measures represent techniques like information dissemination and persuasion, and a wide variety of behaviour change systems to nudge and motivate people towards wanted travel behaviour changes that seem voluntary for the citizen when the measure is working as expected. Gamification has a great potential to enhance certain soft measures, and it can be used to involve citizens in the decision-making process with participatory engagement when planning policies, programs, or measures to promote sustainable transport (Hassan and Hamari, 2020).

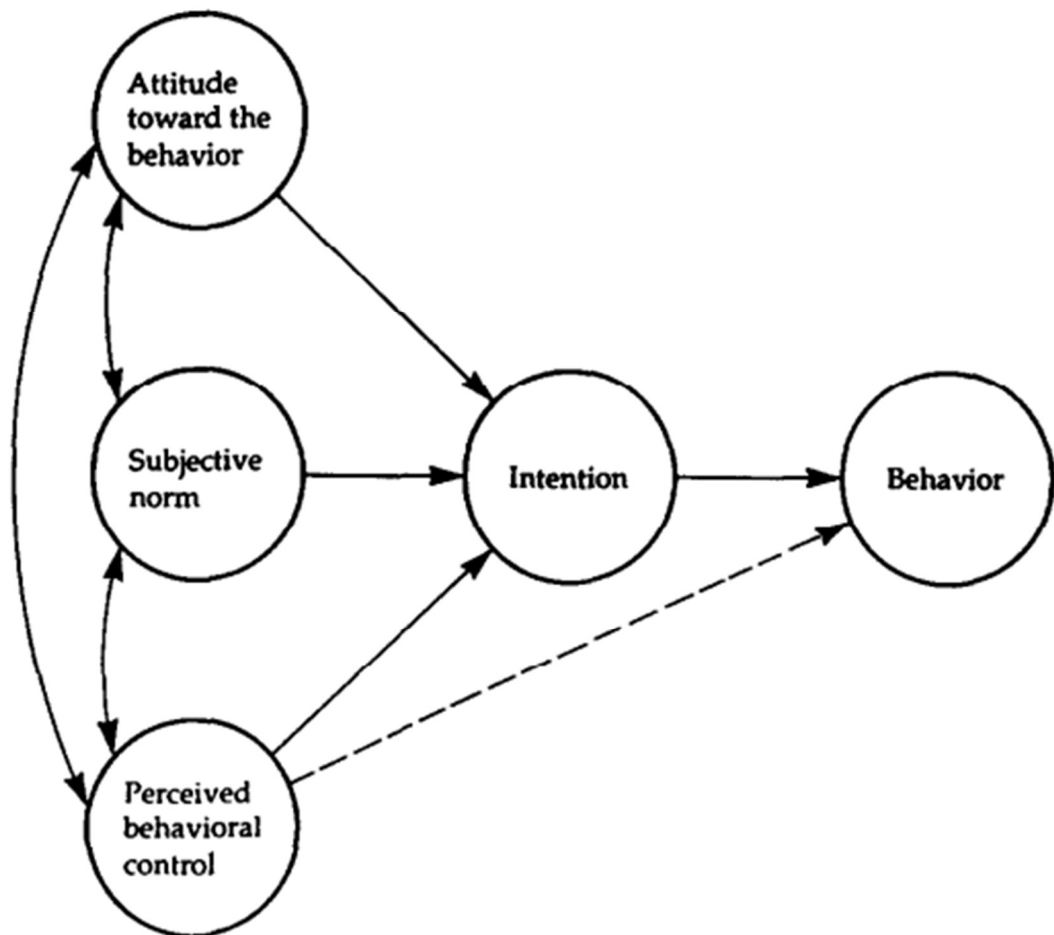
To promote sustainable transport, both soft and hard measures are important and complement each other. Because of gamification's potential to enhance mainly soft measures, this thesis will focus on the different possible applications of soft measures and their synergies with gamification.

### **1.1.2 Travel behaviour change research**

Travel behaviour research emerges from a diverse research field, that naturally combines information from different technical and humanistic fields of science for cross-disciplinary studies. Studies vary by subject demography, situation, intervention measures and instruments, and targeted behaviours in the sense of what kind of transport behaviour change is investigated. This thesis examines how gamification can be used as an intervention instrument and how it can enhance measures or other instruments to change travel behaviour to increase the usage of sustainable modes of travel in different demographics in normal circumstances without any special situation occurring necessarily.

A common way to examine travel behaviour is to use "The theory of planned behavior" by Ajzen (1991). The central factor in this theory is the intention to perform a behaviour and the factors affecting the intention. As a general key rule, the stronger their intention

towards engaging in the action is, the more likely they are to be engaged in such a behaviour. Attitude towards the behaviour, subjective norms, and perceived behavioural control affect the strength of the intention and each other as Figure 2 presents. Attitude towards the behaviour consider how favourable or unfavourable the evaluation or appraisal of the behaviour is. Subjective norm is formed of the perceived social pressure about the behaviour. Perceived behavioural control reflects the past experiences and anticipated challenges of the behaviour. In general, more favourable attitude, subjective norm, and perceived behaviour control leads to a stronger intention to perform the behaviour. When a person has alternative behaviour options, the behaviour is chosen based on the relative strength of the intentions (Bamberg et al., 2011).



**Figure 2.** Theory of planned behavior (Ajzen, 1991)

To understand the “Theory of planned behavior” (Ajzen, 1991) in the transport context, it could be reviewed in the context of commuting by cycling. Attitude forms from the balancing between favourableness and unfavourableness of factors like intrinsic motivation

to behaviours such as exercise, values towards not using a car, physical strain, safety concerns, or the general enjoyment of the ride. Social norms towards the trip form from the communal values of social groups the person is a part of, campaigns, or car-centric norms that arise from the city planning or internalized values and norms. Perceived behavioural control in this context can form from factors such as the burden of cycling the commute, the difficulty of navigation, the condition of the bicycle, travel time difference, price of commute, and pleasantness of the commuting environment. Based on these factors a person forms their intention, and the strength of the intention can be used to predict the possibility of a person to commute by using a bicycle. Gamification can be part of encouraging all of these three factors towards intentions that produce the desired behaviour.

One example of ways to affect behaviour is Behaviour change support systems (BCSS). “BCSS is a sociotechnical information system with psychological and behavioural outcomes designed to form, alter, or reinforce attitudes, behaviours, or act of complying without using coercion or deception” (Oinas-Kukkonen, 2013). Planned interventions with behaviour change support systems affect the “Attitude toward the behaviour” and “Perceived behavioural control” in the Theory of planned behaviour framework (Ajzen, 1991). BCSS will be examined more thoroughly in chapter 3.4.3.

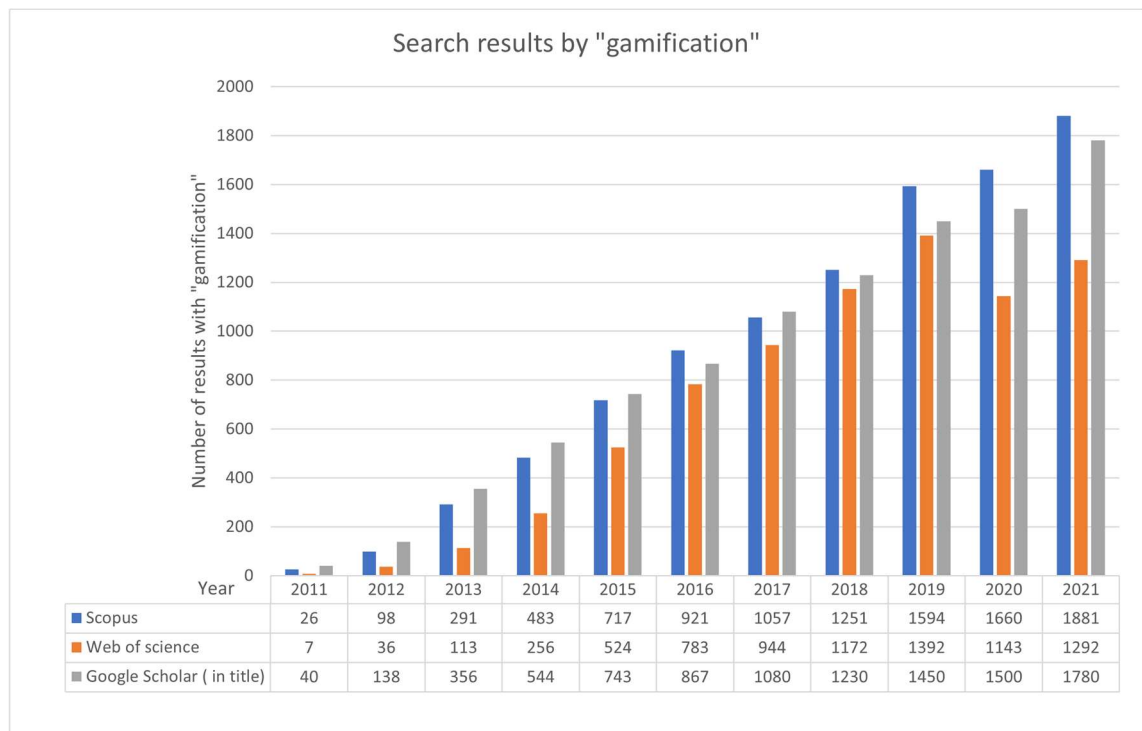
### **1.1.3 What is gamification?**

The origins of gamification are in the science of human-computer interaction. Early examples of these origins are in the development of user experience. Studies that are comparable and parallel in principle to what identifies today as gamification could as an example investigate the importance of software design that is easy to use and learn, user-friendly, and productive (Carroll and Thomas, 1988), or the benefits of intrinsic motivation that games can provide and the design implementations which can encourage the intrinsic motivation (Malone, 1981).

After starting to connect the emotions and experiences of users, it still took more than a decade before gamification as a term was coined. It could be argued that the term was coined in the year 2008 in a blog post by James Currier (2008), or in the year 2002 when Nick Pelling used the term on the website of his consultancy Conundra (Pelling, 2002). When trying to find the origin of gamification it is important to see that alongside the term gamification, there have been parallel terms, and new parallel terms are being introduced (Deterding et al., 2011). Some of these parallel terms can be seen as a synonym or otherwise close in meaning with gamification depending on the definition of choice. Despite these parallel terms and gamification having a history of being a contested term in

some industries and communities, it has become the recognized and institutionalized household term (Deterding et al., 2011).

After 2010 gamification started to gain interest and attention among the academic community. Figure 3 shows the rise in interest in gamification by showing the number of academic publications from each year between 2011 and 2021 that were found from three different academic search engines.



**Figure 3.** The chart shows the steady and steep increase in search results of academic papers from different years for the keyword “gamification” in three different academic search engines.

Seaborn and Fels (2015) examined gamification in a literature review where surveyed papers were organised by application domain to survey how gamification was used in action. In their literature review education was the most researched domain in the applied gamification research. To a lesser extent health and wellness, online communities, crowdsourcing, and sustainability were also researched domains. It is good to notice, that after the literature review by Seaborn and Fels was published in 2015, research on gamification has been increasing a lot as Figure 3 presents. Nevertheless, the survey has credible case studies that are valuable data points, even if the ratio of the domains may have developed in one way or another.

Some cases of applied gamification research will be examined next to demonstrate how gamification is used in action. These cases offer a better understanding about different

applications under different domains, and the mechanics they have used in the gamifying process.

The first example considers how education can be gamified using badges and achievements as a gameful mechanic. McDaniel et al. (2012) created an online course management system which enhanced a course titled “Adventures in Emerging Media” by adding badges and achievements to promote specific types of student behaviours and designing course to allow students to choose their own pathways through the learning content, and by that creating “a choose your own adventure” structure which is familiar in the world of video games.

Badges and achievements follow the story to show students how they progress. Another function of badges and achievements is to motivate students. As an example, students were given a badge if they completed the midterm or final exam two days before it was due. Badges were visible in the achievement section of the course where students can see a leaderboard and compare their badges against each other. Overall response to the gamification of the course was positive. Reaction to the course structure and narrative was positive, and it was found that the badges motivated many students.

The second example is about gamified health intervention. Smith-McLallen et al. (2017) studied the effects of a standard walking program and enhanced program that included incentives, feedback, competitive challenges, and monthly wellness workshops. The sample consisted of groups of employers that met the criteria for the study, and they were randomly assigned to a condition. Groups were informed about the other groups, but they were blinded to the existence of the other intervention conditions. Participants completed the baseline questionnaire or received baseline biometric screening, and after that they were given an accelerometer to record their steps and access to a website to log their steps. They were instructed to wear the accelerometer for all walking hours 7 days a week.

Enhancements were walking challenges developed by the research staff, bi-monthly feedback regarding their walked miles, and tokens for every 10 000 walked steps which were tradeable for prizes such as gym bags and cookbooks. Groups could also compare themselves to other groups and see the progress of each group. Enhanced groups also received material to encourage walking at the workplace including posters, walking maps for walks of at least 1 mile near the workplace, and monthly wellness seminars consisting of setting walking goals, overcoming barriers to reaching those goals, stress reduction, and developing healthy eating habits (Smith-McLallen et al., 2017).



Program participation, average daily step counts, biometric outcomes, and psychologic outcomes were evaluated. Results show that the enhanced intervention had a stronger positive effect with a higher average step count, higher likelihood of achieving 10 000 steps, and higher percentage of participants logging their steps frequently for the whole study 9-month study period. As expected, the study demonstrated positive changes in several health outcomes (including improvements in physical and mental health) associated with higher step counts (Smith-McLallen et al., 2017).

The article had no mention of using gamification, still the intervention used gameful and playful mechanics to create gameful experiences such as rewarding participants, giving feedback, making challenges, guiding, competing, and creating social experiences (Högberg et al., 2019). As an interesting finding, one standard condition group whose program administrator introduced their own program enhancements for their group, led to that group having participation rates that were close to the rates of groups with enhanced condition, demonstrating the strength of a higher level of promoting to produce higher levels of engagement.

The third example is a location-based mobile game called Foursquare, which is an interesting option as a tool to make an impact on travel behaviour. Travel behaviour impact would in theory arise from the potential of derived travel demand of the application. The basic idea of Foursquare is to register yourself to the locations you visit such as pubs, libraries, or airports to collect badges, share the places you have visited with your friends, or if you are the person that has the most registrations in the location in a certain timeframe you gain the “mayorship” of that location. Frith (2013) studied Foursquare and found out that the use of Foursquare altered depending on how people interact with their surrounding spaces, because the digital layer of information that the application provides alters the experience of the physical place, which contributes to the development of a so-called hybrid place, and by that adds interest to the location for the user. The study found out that Foursquare also had a social impact as a social networking environment, which occurs in the form of sharing your location with your friends, or by becoming a part of how people perform identity using Foursquare. As an example of identity building, one interviewee had added a certain kind of restaurant to their list of mayorships to communicate a certain type of culinary consumption for their network in Foursquare.

These three examples are quite obvious applications of using gamification. All three examples altered mundane functions of education, walking, and visiting locations, and added gameful elements to them or transformed them into a game. For this thesis, it is

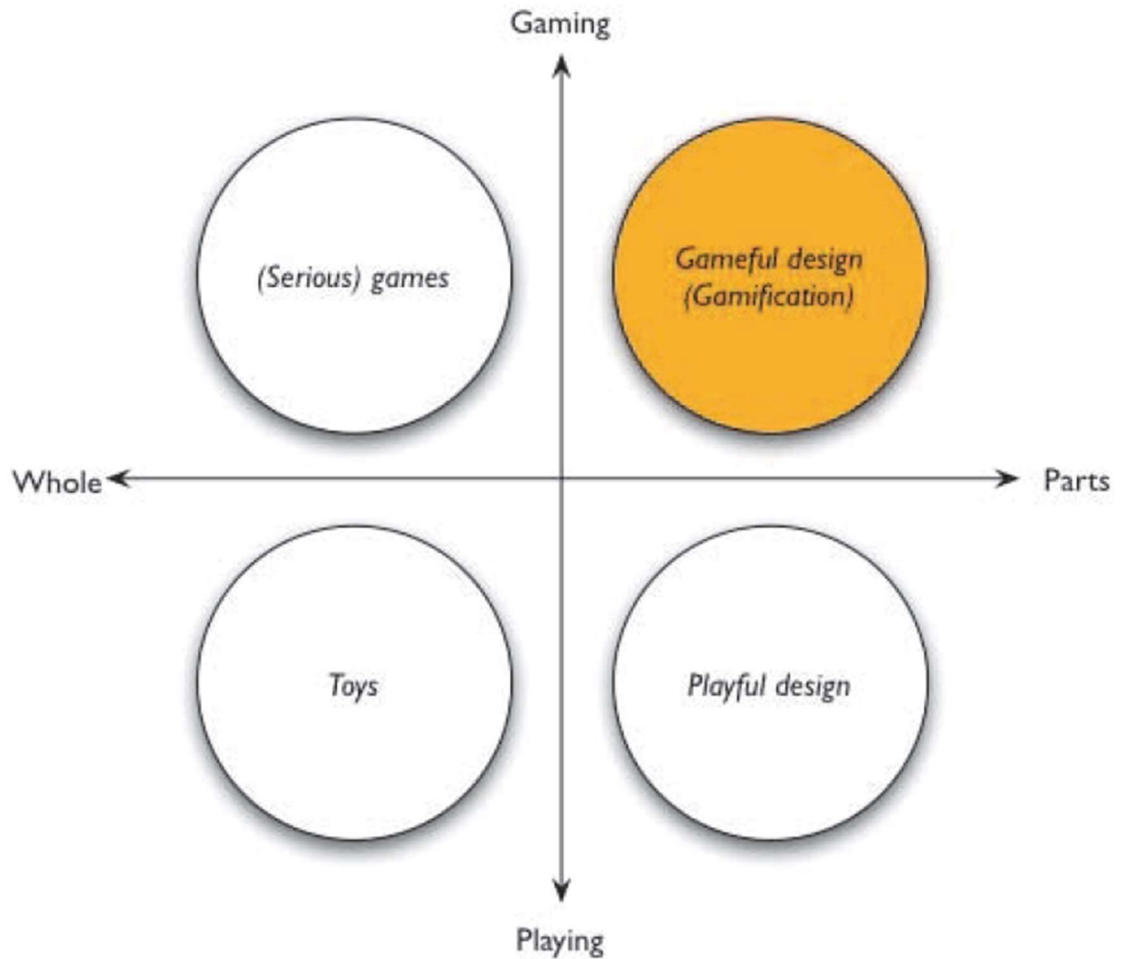
essential to define gamification better to find out also the less obvious ways and opportunities to gamify functions, and to find out the framework and limitations on which the research of the thesis will be built.

#### **1.1.4 Definition of gamification**

There are two definitions that seem to be the most common in the gamification literature. Next, we will go through these two definitions, and justify the choice of definition that this thesis will use to reach the most useful and valuable outcomes.

Gamification is “the use of game design elements in non-game context” was proposed as a definition in 2011 (Deterding et al., 2011). The definition is easy to understand in nature, but if it is examined in more detail, the definition reveals its restrictions.

Deterding et al. (2011) emphasise the usage of games in. In this definition games need to have explicit rule systems, and competition or actors working towards discrete goals and outcomes. The usage of game elements and design choices determine if the solution is a full-fledged game, or a gamified application that has been built with the intention of a system that includes elements from games. Examples of these elements that Deterding et al. (2011) used were the “Ten Ingredients of Great Games” (Reeves and Read, 2009) which are self-presentation, levels, narrative context, ranks, teams, time pressure, feedback, economies, marketplaces, three-dimensional environments, and parallel communication systems that can be easily configured.



**Figure 4.** Deterding's definition is a way of separating gamification by the type of usage and characteristics of the game in the solution (Deterding et al., 2011)

In the perspective of this thesis, the diversion between games and play is important. Games and play were separated into *paidia* (playing) and *ludus* (competing), and in this definition of gamification, only a design built on principles of *ludus* should be considered as gamification (Deterding et al., 2011). The main difference between the concept of *paidia* compared to *ludus* is the lack of rules and formal structures in the act of play or games. *Paidia* is the spontaneous manifestation of the instinct to play and seek disturbances in life, with childlike primitive remains of personality that will contest the rational and rule-seeking homo economicus in us (Caillois and Meyer, 2001).

I would argue that the spontaneous character of *paidia* is important when the goal is to affect transport behaviour, especially when the goal is to increase walking. Walking is a mode of transport where in addition to transport, people have informal and uncomplicated opportunities to be present in their surroundings (Gehl, 2011). Many people can explain if they like their walking route, but the environments influence the walking experience often unconsciously (Hillnhütter, 2022). For pedestrians, the experienced travel

time and perceived distance depend on multiple different factors about the quality of the route that affect a person's opinion on the acceptability of transport mode for the transition in question (Gehl, 2010). Because of various experience and feeling-based factors that many unconsciously encounter, it is sensible to not exclude playfulness and playful designs from the tools for intervention of behaviour change that aims for increased usage of active transport modes.

Another well-known definition of gamification is from a paper focusing on gamification from a service marketing perspective by Huotari and Hamari (2012). This definition for gamification is "a process of enhancing a service with affordances for gameful experiences in order to support user's overall value creation". This definition emphasises the experimental nature of games and gamification instead of the systematic understanding, which relies on the notion that gamification is based on the use of game elements. One reason for this is that it is hard to define elements that are unique strictly to games. When a game is distinguished from a gamified system based on only game elements, many services could be concluded as games regardless of the subjective experiences of a user. Also, gamification is not always carried out through any concrete game elements alone. Because of this Huotari and Hamari argue that the definition of gamification cannot be based on a set of methods or mechanics, but instead "it has to be understood more broadly as a process in which the gamifier is attempting to increase the likelihood for the gameful experiences to emerge by imbuing the service with affordances for that purpose".

Service marketing is a great context to use when affecting travel behaviour because they both have similar interests in changing attitudes and habits. After all, promoting modes of transport is marketing in its core.

The definition of "service" in the transport behaviour change context could be the infrastructure and city as a whole, including navigation systems, the experience of commuting, or any transport related service such as bicycle parking. "User's overall value creation" can be seen as the benefits gained to people, municipalities, governments, the environment, and as an increased mileage of the targeted modes of transport as a result that the solution can provide when it is successful. "Affordances for gameful experiences in order to support" is in its core about providing and creating resources needed in a physical and psychological sense, to enable the solution to function, and to reach the goals it has set. This definition of gamification will be used for this study and the framework which will be compiled.

## **1.2 Aims**

### **1.2.1 Purpose and target group**

The purpose of the thesis is to offer guidance and knowledge on an introductory level about gamification in the transport context for the target groups, with the goal of defining a framework for the best practices to make it easier to design and implement gamified solutions into transport related promotion programs and their measures. Another purpose is to spread the understanding and information about gamification as a tool beyond the status of being just a trendy buzzword. The third purpose is to encourage and guide people connected to transport engineering to consider gamification as a valuable tool to enhance promotion measures, and to recognise new possibilities in the field of transport behaviour change in general.

The main target group of the thesis are transport planners, urban planners, and designers in charge of developing and designing sustainable transport promotion programs on different scales. The secondary target groups of the thesis are academics of transport research, and decision-makers and policymakers of different levels of administration.

### **1.2.2 Goals and the scope of the study**

The main goal of the thesis is to find ideas to create best practice principles to develop, design, and commission gamified systems to enhance the promotion of sustainable transport systems. With best practice principles, the goal is to introduce the possibility of steering some of the transport behaviour interventions towards gamification and gamified experiences in a way that they can be meaningful and have the best chance to create the wanted impact in the user. Also, I find it meaningful to construct a base-level introduction for people around the transport sectors about gamification and gamified experiences to have agency and influence around the topic when discussing and designing solutions and directions for the future.

The framework that will be constructed in this thesis aims to dissect the process into more feasible smaller parts that could make it easier to focus and reflect on the design and implementation process. Also, it is desired that the provided framework would be flexible enough to be adapted as a helpful tool for retrospective analysis of promotion measures that were enhanced with gamification.

With a better and more organized understanding that the framework could provide, it would be desirable that the professionals of the transport sector can have better opportunities to direct the solutions toward the desired end results. If successful, the framework will provide opportunities to construct successful and inclusive solutions, that are suitable

for the needs of a project. Case studies are needed to evaluate the effectiveness and ability to predict outcomes of projects, and by that the quality of the framework. If the framework turns out to be effective, it is assumed to yield new research opportunities to develop it towards being a widely used and adaptable tool in the diverse field of transport and city planning.

Often transport planning, and to some amount city planning, are perceived as a technical field, and the humanistic factors can be underestimated. Because the end user of the complex entity called a city is a homo sapiens with natural decision-making abilities, it is important to factor in the knowledge and estimations of our thought processes. Therefore, the synergies of technical and humanistic competencies are self-evident and necessary.

Gamification at its core is about the feelings and experiences it raises in a person, the same way our cities and transport systems do intentionally or unintentionally. Therefore, there are natural synergies between the perspectives.

One benefit from the synergy between gamification with transport and city planning is the mandatory consideration of feelings in the design processes that have been evident to some degree from an architectural point of view, but easily lacking in a more technical perspective, or the common sense of layperson. For the goal of developing a modal split towards sustainable transport, the possibility of finding new ways of approaching design processes of promotion measures, infrastructure, city planning, and academic research, there could be a lot of value in using gamification to enhance measures. This could yield case studies about ways that the field of transport can use feelings and experiences, behaviour and attitude change, complying to triggers, and alternative ways of placemaking.

The scope of this thesis is limited to an introductory level, and thus it examines the definition of gamification from a surface level. This choice was made as the goal of the thesis is to introduce professionals of the field of transport to the possibilities of gamification, with easy-to-understand concepts and examples to provide a basic level of understanding, and thus enable them to participate in processes where gamification is used in their field. This led to the methodology choices within the literature review and evaluation of the case studies to provide results that are enough simple and understandable for the reader within the limits of good scientific practices.

### **1.2.3 Research questions and structure**

Three research questions are examined in this thesis. Research question 1 is “Are there linkages between gamification and modal shift towards sustainable transport modes?”. Research question 2 is “What kind of framework can guide the user to design or evaluate transport related solutions that use gamification?”. Research question 3 is “What does the evaluated case studies tell us about gamification in the field of transport?”

The methodology of the literature review, framework, and case studies are explained in chapter 2. In addition, the research philosophy of this thesis is explained in this chapter.

In chapter 3 the theoretical background will be explained, followed by the findings from each recognised key area. After presenting the findings, the framework will be defined in chapter 4.1. After the framework is set up, it will be applied to test five case studies, and see how well it can evaluate their success in chapter 4.2.

After the results chapter, the thesis will advance to discussions and conclusions chapter. In this chapter the research questions, limitations, and future research possibilities will be examined.

## **2. METHODOLOGY**

### **2.1 The research onion as the general basis**

The general methodology of this thesis can be explained with the framework called “The research onion”, which was created by Saunders et al. (2019). By this multileveled framework the methodology of this thesis would use the management philosophy of pragmatism, induction as the approach to theory development, multi-method qualitative as the methodological choice, with strategies of archival and documentary research in combination with case study, cross-sectional time horizon, and data collection is made by reviewing literature and observing case studies, and data analysis with thematic analysis.

In the thesis, pragmatism is evident from the description given by Saunders et al., (2019) in the way that the thesis has its direct aim of supporting future actors in the field of transport without limiting itself too narrow, so it can operate as “instruments of thought and action”. Induction is evident in the way that the findings from the literature are used for the generation of themes, and building of the framework through the theories which are agglomerated to find a cohesive understanding of the topic, in a similar way that Saunders et al., (2019) explains the inductive approach to theory development. Methodological choice of multi-method qualitative is the right approach with the structure and aims of the thesis, as the thesis wants to understand the topic in general and offer guidance about it for those in the field of transport. Chosen strategies and time horizon, in combination with the collection and analysis of the data, follow this approach as the logical way of conducting the research, and enable a feasible and appropriate research plan in contrast to the aims and the amplitude of this master’s thesis.

### **2.2 Literature review**

The literature review was conducted by a thematic analysis based on the chosen definition of gamification, which was explained in chapter 1.1.4. Use cases for thematic analysis that Saunders et al., (2019) described that were used for this review were the identification of key themes from a data set for further exploration, producing a thematic description of this data, and develop and test explanation and theories based on apparent thematic patterns or relationships.

The definition “a process of enhancing a service with affordances for gameful experiences in order to support user’s overall value creation” was dissected into smaller parts to analyse and find what are the key areas to investigate when examining gamification



in a new context. Key areas that were recognised were gameful experiences, affordances, enhancing services, motivation support, and value creation. These key areas were seen as categories where the chosen papers were allocated to present different aspects of the definition, and thus the different sections of the literature review were formed.

In addition to finding information about the key areas of definition, gamification as a general research topic was examined to better the general understanding of the topic and help to recognise the important factors of gained information in regard to building the framework. References found from the general research were a good way of finding the definitive work of the area, which was critical for finding the linkages between the fields of gamification and transport, understanding the principles of gamification, and strengthening the justification and outlining of the key areas of gameful experiences, affordances, enhancing services, motivation support, and value creation. These studies were used mainly in sections 1.1.3 and 1.1.4 to build a background for this thesis.

The literature used in the literature review was sourced from Tampere University Library's printed and electronic archives, and other academic search engines such as Scopus and Google Scholar. Naturally, some of the included literature was found as references of examined articles. Search entries varied a lot based on the researched theme in question. Often the search entry was made from a combination of different key areas that were researched at the time in combination with a common search term to narrow the results. Examples of these common search terms could be "gamification", "transportation", "transport", "sustainability", "sustainable transport\*", "cycling", "walking", "public trans\*", "city planning", or "urban planning". While researching the key areas, the previously mentioned search terms were used in combinations with the terms among the key area in question. Also, references of the found papers were crucial sources for additional references with many key areas. Papers were chosen if they examined the theme in question from a perspective that was seen as relevant to the thesis.

## **2.3 Identification of the framework**

After the literature review was completed, development of the framework started. The goal was to create an easy route to examine all the key areas in a logical order. This was done by figuring out what parts of the service each key area presented, and what sort of information can support the latter steps of the framework.

The order that was seen as the most logical, and thus chosen, was to start examining from a basic level of the service's main features and goals (enhanced services, and behavioural change). After this, the framework encourages to recognise systems that the service relies on (motivation support, and affordances). As the last step, the framework concludes what kind of gameful experiences the service might produce, and how these experiences should be classified.

## **2.4 Case Studies**

Case studies were chosen with the goal of finding five different services among the transport sector that could stand for various kinds of goals, and that might be gameful. This process started by drafting a list of services that included items such as "A transport game" (MUV Game), "Transport related crowdsourcing" (Crowdsorsa), "Mundane everyday transport intervention" (Workplace competition to promote commuting with bicycle), "City wide gamification related event" (CitiCAP), and "General view on urban design" (Cities in general). Items on this list were considered based on the hypothetical and probable needs of services, tasks, and projects that the wide array of professionals in the transport sector might encounter in their careers. Chosen case studies related to items on the list are mentioned in parentheses.

Analysis and evaluation were made by following the steps of the framework, with the information found from articles and websites. Also, common knowledge and experiences were used to fill in some information about themes that could be generalised naturally.

## 3. RESULTS

### 3.1 Gameful experiences

#### 3.1.1 Defining gameful experiences and GAMEFULQUEST

Högberg et al. (2019) developed an instrument for measuring gameful experiences while using a service. The instrument was called Gameful Experience Questionnaire (GAMEFULQUEST). This model of gameful experiences was developed with a study, which was built with data from a questionnaire which consisted of open-ended questions for users of services Zombies, Run!, Duolingo, and Nike+Run Club. After this, the instrument was developed in a latter study which used data from users of Zombies, Run! and evaluated the dimensionality and psychometric properties. From the results of this study, a third study was conducted with the goal of further developing the instrument by assessment of the dimensionality and psychometric properties with data of Duolingo users. As a result of these three studies GAMEFULQUEST was created and validated.

In their research Högberg et al. (2019) stated that the goal of creating gameful experiences is to motivate users towards target behaviours, and to continue service use if the service is not meant to be used only for a fixed period. Gamification cannot be distinctly split into hedonic (e.g., joyful, entertaining, and exciting) and utilitarian (e.g., practical, functional, and essential) purposes in the way van der Heijden (2004) recommends in their study about user acceptance of information systems. Reason for this is that the gameful experiences are often both hedonic and utilitarian, and mix them in a way which provides the affordances for the motivation support or an equivalent for the wanted outcomes (Hamari and Koivisto, 2015).

Högberg et al. (2019) formed findings from their analyses of the survey responses and previous research. Their analysis found existing themes and new ones. These themes were then made into the dimensions of gameful experiences, which will be also used as a guideline for this thesis' classification of gameful experiences. Dimensions found in their study are accomplishment, challenge, competition, guided, immersion, playfulness, and social experiences. By having these dimensions guiding the research, the considerations about gameful experiences in sustainable transport will be easier and more solid.

Next, the dimensions and their definitions will be examined, and their differences, strengths, and weaknesses are contemplated. Also, some examples of the items selected for the final version of GAMEFULQUEST will be shown to explain what kind of experiences and outcomes they represent.

**Table 1.** Dimensions and their definitions in GAMEFULQUEST (Högberg et al., 2019)

Dimension	Definition
Accomplishment	Experiencing the demand or drive for successful performance, goal achievement, and progress
Challenge	Experiencing demand for great effort in order to be successful, thus the ability of the person is tested
Competition	Experiencing rivalry towards one or more actors (self, other person, service, or group) to gain a scarce outcome that is desirable for all actors
Guided	Experiencing being guided on how (including what and when) to do, and on how to improve the target behavior
Immersion	All attention is taken over, and the person experiences being absorbed in what he or she is doing, while having a sense of being dissociated from the real world (of time, of own actions, or of space)
Playfulness	The experience of being involved in voluntary and pleasurable behaviors that are driven by imagination or exploration while being free from or being under spontaneously created rules
Social experience	The experiences emanating from the direct or indirect presence of people (both present in the real world and in the service), service-created social actors, and service as a social actor

Accomplishment is the gameful experience which motivates the user to the goal or target behaviour. The rewarding and proud feeling of achieving and progressing in the given task drives the user to change their behaviour. Items included in the final version of GAMEFULQUEST about accomplishment were as an example “Pushes me to strive for accomplishments”, “Motivates me to progress and get better”, “Makes me strive to take myself to the next level”, “Inspires me to maintain my standards of performance”, and “Gives me the feeling that I need to reach goals” (Högberg et al., 2019). When using accomplishment as a gameful experience, the effect is probably suitable as a first nudge towards wanted behaviour, but the long-lasting effect might be hard to contain. Accomplishment is also a common experience in non-gamified contexts. As an example, when a person is achieving personal goals in sports.

Challenge is in its nature similar experience to accomplishment. Challenge is about the effort and doing the behaviour, rather than the outcome, especially in comparison to competition, which focuses more on challenging the ability of the user. This can also be seen as a negative if the person experiences disappointment or frustration from the inability to cope with the pressure or expectations of the challenge. Items included in the final version of GAMEFULQUEST about challenge were as an example “Makes my push

my limits”, “Motivates me to do things that feel highly demanding”, “Challenges me”, “Pressures me in a positive way by its high demands”, and “Makes me work at a level close to what I am capable of” (Högberg et al., 2019).

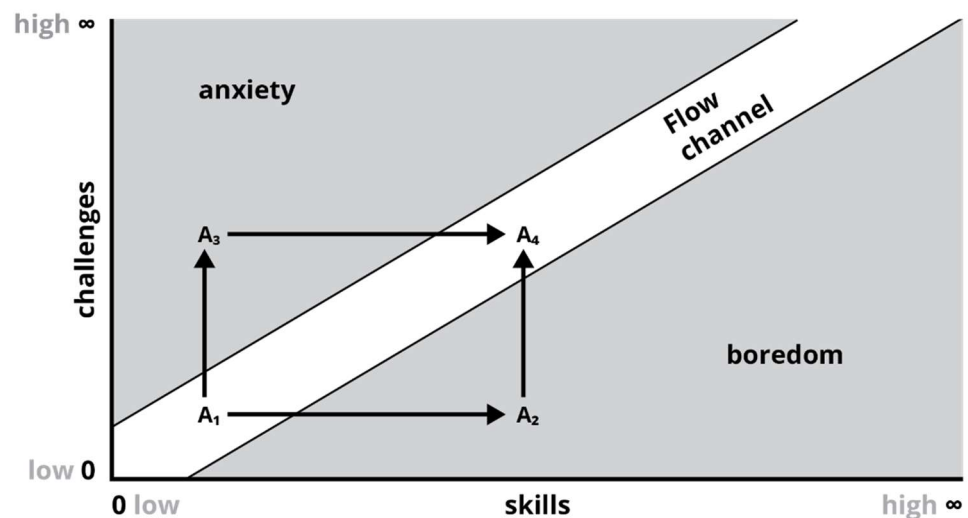
Competition is another experience quite close to challenge and accomplishment. What differentiates competition from challenge and accomplishment is the social elements of competing. To simplify, challenge against other participants to gain an accomplishment is competition. The phrase “competing against yourself” is closer to challenge or accomplishment in this definition of the gameful experience dimensions. The social aspect of competition has a risk of developing anxiety in the participants, in a similar fashion to challenge. Items included in the final version of GAMEFULQUEST about competition were as an example “Inspires me to compete”, “Involves me by its competitive aspects”, “Makes me want to be in first place”, “Feels like participating in competition”, and “Feels like being in a race” (Högberg et al., 2019).

Because of the similar nature of accomplishment, challenge, and competition, they are easily combined or mixed with each other. The main differences often are that accomplishment aims mostly at the end result, challenge aims at the process, and competition aims at the comparison between users or contestants.

Guided is a gameful experience which focuses on helping the user to perform or improve in the wanted task. The main function of providing the experience of being guided is to help the user, which may lead to higher motivation as a consequence of learning the behaviour or improving in it. Feedback from being guided can also lead to positive enforcement. This learning component makes guided a unique dimension in GAMEFULQUEST. Items included in the final version of GAMEFULQUEST about guided were as an example “Makes me feel guided”, “Gives me a sense of being directed”, “Gives me the sense I am getting help to be structured”, “Makes me feel like someone is keeping me on track”, “Gives me the feeling that I have an instructor”, and “Gives me useful feedback so I can adapt” (Högberg et al., 2019).

Immersion is an experience which absorbs the person. Immersion as an experience has a lot in common with the experience of flow and they overlap in many ways. Csikszentmihalyi (2000) described flow as a state of mind when action follows upon action according to an internal logic, without the need for conscious interventions by the person leading, to the person experiencing “unified flowing from one moment to the next, in which there is little distinction between self and environment, between stimulus and response, between past, present, and future”.

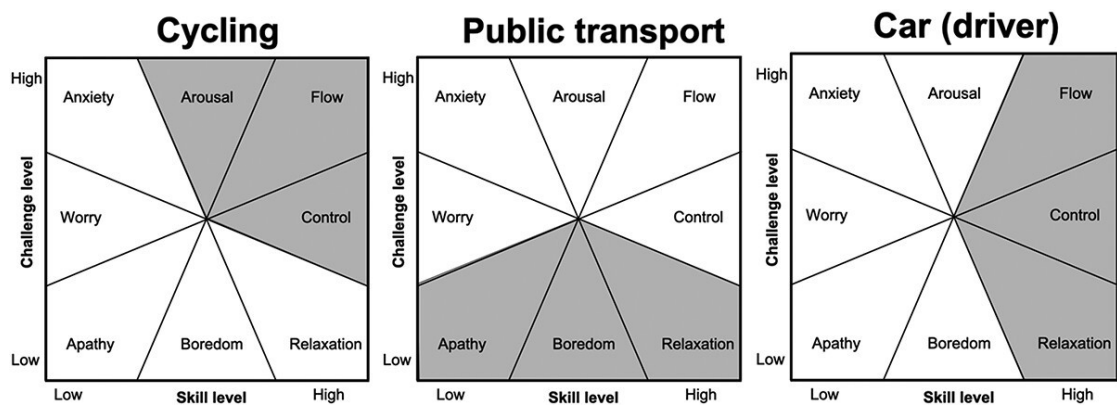
Csikszentmihalyi (2008) introduces a diagram (Figure 5) to demonstrate the finding of flow state. It is explained that A represents a tennis player named Alex.  $A_1$  is a state where Alex starts to play tennis and finds it enjoyable, even with low skill level and little challenge, because the challenge and Alex's skills are in good balance. After a while of practising, Alex's skills will develop, and the old challenges of basic practising will get boring. At this point Alex has moved to point  $A_2$ . From point  $A_2$  Alex must find some kind of new practice routines or match opponents to get back to the flow channel in point  $A_4$ . If Alex while being at point  $A_1$  would find an opponent who is too good, and by that presents a too high challenge for Alex, he would move to point  $A_3$ . From point  $A_3$  Alex must better their skills and/or find the less challenging environment to get to the point of  $A_4$  and get back to the enjoyable flow channel. Although  $A_4$  is enjoyable, it is also a complex state of mind, which is not stable and needs similar or even more complicated adjustments, as Alex did after leaving point  $A_1$  (Csikszentmihalyi, 2008). Otherwise, Alex would get tired of the boredom or the anxiety arising from the frustrating skill level, which leads to Alex not enjoying the act.



**Figure 5.** Simple diagram about the flow channel and the flow experience. Recreated from the original diagram of Csikszentmihalyi (2008)

In the transport context travel modes that involve physical movement associated with deep bodily involvement and relatively high control over the trip offer opportunities for experiencing flow. Although, flow experience can appear also in less physical movement as an example when sitting in a public transport vehicle, by allowing the person time to do other enjoyable activities (Te Brömmelstroet et al., 2022).

Te Brömmelstroet et al. (2022) also revised the diagram by Csikszentmihalyi (Figure 5) and made it more complicated so it can show mental states that responders of their study were frequently experiencing while travelling with their primary mode of transport. This revised diagram can be seen in Figure 6. In Figure 6 the often-felt mental states in each of the primary modes of transport are highlighted with grey colour.



**Figure 6.** Reworked diagram of mental states while travelling with the primary mode of transport from the results of the questionnaire. The diagram is inspired by the original design by Csikszentmihalyi (Te Brömmelstroet et al., 2022)

To translate the tennis example Csikszentmihalyi (2008) used to explain Figure 5 in the transport context with the help of Figure 6 and the findings of Te Brömmelstroet et al. (2022), Alex will start to use public transport. In this example, in point  $A_1$  Alex is used to use a simple public transport system occasionally in a manner where the journey is not too familiar, and keeps Alex engaged in the travel with new views and interesting experiences from it. After a while, Alex gets used to the journey and Alex's mental state moves to point  $A_2$ . To battle the boredom Alex starts to add stimulus to the journey by reading a book, and beginning a challenge at the workplace where Alex tries to minimize the usage of private car usage. With this extra stimulus, Alex moves to point  $A_4$ , at least for some amount of time. Also, Alex might find the boredom of the journey relaxing and feel no need to gain stimulus to reach the optimal experience and flow. As an alternative path from point  $A_1$ , Alex will move to a new bigger city with a complicated public transport system, which is hard to navigate with the low skills in using the public transport system in question. This leads to Alex's state of mind to move to the point  $A_4$ , and Alex feels anxiety about using the public transport system, which leads to negative experiences about the public transport system. Alex decides to stick with using the public transport system, or Alex finds a solution to ease the use, which leads to an increase in skill, and returns Alex to the flow channel with optimal experience in point  $A_4$ . With time, the state

of mind might go back to point A<sub>2</sub>, and then Alex is faced with similar options as presented before. This constant change and development represent the unstable nature of the experiences.

When immersed, the person feels a change in their perception of their surroundings and the real world. Immersion can even help the person to forget some of their real-world problems and strengthen their feeling of involvement in the city. This can lead to time passing quickly, and by that perceived travel time becomes shorter, which leads to a positive evaluation of the commute experience (Li, 2003). Immersion can ease the targeted behaviour by making it less effortful, and by providing a diversion to help people who need it to cope with the targeted behaviour (Högberg et al., 2019). Items included in the final version of GAMEFULQUEST about immersion were as an example “Makes me lose myself in what I am doing”, “Makes me ignore everything around me”, “Gives me the feeling that time passes quickly”, “Causes me to forget about my everyday concerns”, “Causes me to stop noticing when I get tired”, and “Gets me fully emotionally involved” (Högberg et al., 2019).

Högberg et al. (2019) described playfulness as pleasure arising from the room left for imagination and creativity, spontaneity, and explorative aspects which were even described as mystery. One way to enable spontaneity and exploration in commuters is to arrange sections of the city in paths with the elements as the network of habitual or potential lines of movement through the urban complex (Lynch, 1960). This kind of playful city design can also spur immersion in the commuter. Högberg et al. (2019) noted that voluntariness is important, and compulsory would reduce the probability of completing the action. Items included in the final version of GAMEFULQUEST about playfulness were as an example “Gives me the feeling that I explore things”, “Makes me feel like I discover new things”, “Appeals to my curiosity”, “Feels like a mystery to reveal”, “Gives me an overall playful experience”, “Taps into my imagination”, “Makes me feel that I can be creative”, “Makes me feel like I’m developing something”, “Leaves room for me to be spontaneous”, and “Gives me a feeling that I want to know what comes next” (Högberg et al., 2019).

In GAMEFULQUEST social experience is defined as a gameful experience which arises from the presence of real or made-up people in the real world or the service (Högberg et al., 2019). The motivation to perform the task is rooted in the feeling of accountability, support, and participation. Items included in the final version of GAMEFULQUEST about social experience were as an example “Makes me feel like I am socially involved”, “Gives me a feeling of being connected to others”, “Feels like a social experience”, “Gives me a



sense of social support”, “Gives me a sense of having someone to share my endeavours with”, and “Gives me the feeling that I am not on my own”.

These defined dimensions of gameful experiences ease the process of understanding the differences and synergies between the dimensions, and by that they become more approachable for people outside the field of gamification to understand them and the possibilities they offer. With the items of GAMEFULQUEST (all items included in the final version instead of only the examples given earlier in chapter), the needs and goals of the gameful experiences in planned gamified solutions can be mapped and different options can be considered (Högberg et al., 2019). On the other side, when gamified solutions are evaluated, these items can be used as a checklist to understand what kind of gameful experiences the solution has, and how well those experiences come true. The questionnaire can in principle be also used as an instrument to find unintentionally gameful aspects of transport policies and such, but the instrument has not been properly tested and validated for this purpose yet.

### 3.1.2 Play and games

In chapter 1.1.4 terms *paidia* and *ludus* were examined as a key part of *Man, Play and Games* by Caillois and Meyer (2001). Other key terms of classification used in *Man, Play and Games* were *agôn*, *alea*, *mimicry*, and *ilinx*. These terms are a good instrument to classify what kind of gameful experiences the evaluated gamified service is aiming at. Next, these classification categories will be reviewed in a context relevant to the thesis, and their compatibility with the dimensions of GAMEFULQUEST.

**Table 2.** Classification of games with examples in *Man, Play and Games* (Caillois and Meyer, 2001)

	AGÔN (Competition)	ALEA (Chance)	MIMICRY (Simulation)	ILINX (Vertigo)
PAIDIA ↑ Tumult Agitation Immoderate laughter	Racing Wrestling Etc. } not regulated Athletics	Counting-out rhymes Heads or tails	Children's initiations Games of illusion Tag, Arms Masks, Disguises	Children "whirling" Horseback riding Swinging Waltzing
Kite-flying Solitaire Patience Crossword puzzles ↓ LUDUS	Boxing, Billiards Fencing, Checkers Football, Chess  Contests, Sports in general	Betting Roulette  Simple, complex, and continuing lotteries*	Theater Spectacles in general	Volador Traveling carnivals Skiing Mountain climbing Tightrope walking

Caillois and Meyer (2001) define *agôn* as a competition in which people confront each other in certain conditions with the aim of achieving the winner's triumph in a matter where the winner is better than the loser in a certain category of exploits. Because of

this, the practice of *agôn* presumes the desire to win and recognition of their superiority in each area. *Agôn* is seen as quite natural to people. Caillois and Meyer (2001) note that *agôn* is often seen in children as soon as their personality begins to assert itself. Unusual challenges where children might be competing are frequent. An example of this could be staring contests. Natural or not, it is still important to remember that everyone does not enjoy the competitive aspect of play and games.

*Agôn* can be seen in many dimensions of GAMEFULQUEST. Competition is a dimension which is by its name linked to *agôn*, and their compatibility and similarity are relatively high. Dimensions of challenge and accomplishment are in their principles near competition, and *agôn* can apply to them. To experience challenge, a person tries to overcome obstacles and themselves to be successful, in a way which could translate into a person confronting themselves to achieve the earlier mentioned winner's triumph and recognition of their superiority, which can lead to a person experiencing accomplishment from overcoming themselves, and social experience from the recognition of their accomplishment or from the external social support to reach it. In the same kind of circumstances, a causal chain where accomplishment and social experiences appear can also arise when a person is in competition, which leads to them experiencing competition along with challenge.

*Agôn* is a common element in solutions which use gamification, thus it is also common along gamified transport promotion measures. As an example, competition of *agôn* can be as used to promote sustainable transport modes to children (Hunter et al., 2015), affect route choices, frequency, and intensity of training for recreational cyclists (Barratt, 2017), better participation and motivation in workplace cycling campaigns (Millonig et al., 2016), and other practices ranging from the very obvious solutions using competitive elements like leaderboard or points to keep the score of the competition to less obvious where the competition might be as an example internal feeling of progressing.

In summary, *Agôn* is an essential part of many gamified travel behaviour-changing solutions. *Agôn* can be connected to all of the GAMEFULQUEST dimensions.

*Alea* is a game type which is reliant on chance and reveals the destiny of the person in the circumstance. The name originates from the Latin name for the game of chance, or gambling (Caillois and Meyer, 2001). In *alea* user surrenders the responsibility of the outcome to chance instead of their own capability. Compared to *agôn*, *alea* is harder to see in the transport context, or as a way to develop behaviour change. *Alea* can also be mixed with other classifications, and that can lead to synergies which mutually improve both sides.

In the transport context, *alea* is rarer than *agôn*. Since *alea* is a “vindication of personal responsibility” (Caillois and Meyer, 2001), it probably has less motivating potential as the person gives up control. *Alea* might be part of promotion campaigns if a raffle price is offered as a reward, but it probably does not awake as strong motivation as a price which is earned.

An example of *alea* in the travel behaviour context is the speed camera lottery which was presented in the study by Diewald et al. (2013). The speed camera lottery was a demo conducted for three days in Stockholm. The core idea of the speed camera lottery was to identify passing cars on a certain road and enter the law-obeying drivers into the lottery, which consisted of money pooled from a certain portion of the fines collected from the drivers who were speeding. The chance of winning the pooled money gave an extrinsic motivation for the driver to obey the speed limit, and that caused a change in travel behaviour. Diewald et al., (2013) reported a drop in average speed from 32 kilometres per hour to 25 kilometres per hour but noted that they were uncertain if the same effect would have taken place with a normal standard traffic camera, and assumed that as an undesired side effect, the traffic on the road could increase as more people would want to enter the lottery. The side effect of increased traffic could be of course also a positive if it is the goal of the campaign. Especially this increase would be beneficial when trying to guide users towards new infrastructure or transport modes.

As second example is the hatching eggs -mechanic of the game Pokémon Go which was studied by Meschtscherjakov et al. (2017). In the game, one of the goals is to collect characters called Pokémon. Some of the Pokémon are achieved by a mechanic where the user is “hatching an egg”, which in practice is an item that the user buys, and to open this person must walk for 2, 5, or 10 kilometres. After the user has walked the length needed to “hatch” the “egg” in the game, the user will receive the Pokémon in the “egg”. The user has the knowledge of what kind of Pokémon can be in the “egg” by the length needed to “hatch” it, but the outcome is unknown until it is revealed after it actually “hatches”. The process motivates the user to walk a certain distance to discover the contents of the egg. In the study, Meschtscherjakov et al. (2017) surveyed the players of the game and found out that the egg-hatching mechanic influences their walking behaviour. Egg hatching could be linked to GAMEFULQUEST dimensions accomplishment, challenge, immersion, social experience, and playfulness.

In general, it could also be argued that *alea* is present when experiencing new environments. If the person is wandering in an unfamiliar environment, every corner can be seen as a game of chance with the stake of seeing or experiencing something new or unexpected, good or bad. To quote Stevens (2007), “chance encounters in the city provide

opportunities for escape from predetermined and ritualized courses of action". This could fit GAMEFULQUEST dimensions of immersion, playfulness, and social experience.

*Alea* is not as common as *agôn* in gamified travel behaviour solutions, but it is not an irrelevant way of producing gameful experiences. GAMEFULQUEST-dimensions where *alea* can be found could be accomplishment, challenge, immersion, playfulness, and social experience.

The third classification by Caillois and Meyer (2001) is *mimicry*, which can also be called simulation. The common element in *mimicry* is the act of believing or making others believe that the person is someone other than themselves. This happens by forgetting, disguising, or temporarily shedding their personality for something other. Stevens (2007) notes that simulation relies on the constant substitution of something for something else.

When *mimicry* is compared to the dimensions of GAMEFULQUEST, immersion is the most obvious dimension, as the experience of immersion is about overtaking the attention of a person and being absorbed in the doing itself (Högberg et al., 2019). Other dimensions that could be connected to the experience of *mimicry* are guided, playfulness, and social experience.

One way to awake *mimicry* is by using avatars. An example of avatar use to motivate behaviour in the transport context could be the mobile phone application "Stand Up, Heroes!", which was developed to motivate commuters to stand up in public transport, especially during crowded times (Kuramoto et al., 2013). In the application user's avatar would gain experience points by "exploring dungeons" in the game portion of the application for standing during the commute, which led to the avatar's abilities to improve. Kuramoto et al. (2013) noted the problems of their implementation in their published journal article but presented the results on the increase of motivation to perform the wanted behaviour of standing in public transport. The long-term effects of the application were not convincing, at least in the version of the application which was used for the study. In the questionnaire given to the participants the most chosen component for the funniness of the application was the item "Watching your avatar's growing up" (Kuramoto et al., 2013).

Stand Up, Heroes could be interpreted as a way of *mimicry* if the user has connected their efforts of standing to the betterment of their avatar. In this way, the digital counterpart of the user is taking the attention out of the behaviour, which in an optimal situation leads to the user forgetting the negative sides and barriers of the behaviour. It could be assumed that this would have a positive effect on the probability of a person engaging

in the desired behaviour, compared to a comparable situation without the experience of *mimicry* arising from the usage of avatars and similar digital counterparts of the user.

To experience *mimicry*, Wallius et al. (2022) note in their study that practices based on reimagining the meaning and functions of the environment and its elements as well as the unusual ways to experience cities should be seen as a form of *mimicry*. As examples of this phenomenon, Wallius et al. (2022) mention skateboarding, parkour, organizing marathons, and games that rely on augmented reality like Pokémon GO. With this kind of definition of *mimicry*, gameful experiences created by city design and events in urban areas can be considered as a part of gameful promotion tools of sustainable transport modes.

Wallius et al. (2022) also mention the marketing of different companies, in this case e-scooter companies Wind and Voi. Wind compares their users to superheroes (e.g., encouraging helmet use by calling the customers helmet heroes) and services as superpowers, with the tagline of “GET SUPER POWERED” (Wind, 2023), trying to generate an experience of *mimicry* in potential customers. As of May 2020, Voi was promoting their e-scooters by claiming to offer “magic wheels” and explaining the riding rules in playful metaphor, by narrating that forbidden sections of streets are made of lava (Wallius et al., 2022), encouraging customers to have a fun and magical standpoint towards the services they offer, which might lead to the customer experiencing *mimicry* while using their services, granted this kind of campaigning is making a certain type of impact on the potential customer.

The fourth and final classification in Man, Play and Games is *ilinx* or vertigo (Caillois and Meyer, 2001). *ilinx* is described as a “pursuit of vertigo and which consists of an attempt to momentarily destroy the stability of perception and inflict a kind of voluptuous panic upon an otherwise lucid mind” (Caillois and Meyer, 2001). To put simply, *ilinx* is about the physical sensations which occur during behaviour, play, physical activity, or from outer sources like roller coaster rides. In the context of identifying a gameful experience which is about *ilinx*, the thesis is interested in solutions which encourage or promise bodily sensations like the examples mentioned previously.

Because *ilinx* is a physical feeling it is more indirect to produce compared to *agôn*, *alea*, and *mimicry*. Wallius et al. (2022) argued that e-scooter companies were using the feeling of *ilinx* to promote their services by using advertising slogans like “Zoom Through the City”. In the same study they pointed out that e-scooters can be used to achieve the adrenaline rush which can be one form of *ilinx* (Wallius et al., 2022). With this logic, the same sort of advertising and promoting could be used in other travel modes like cycling,

or in general in active travel and environments that want to be seen as friendly to active travel. Of course, the promoting content should be aimed at the target demography.

As an example, The City of Helsinki's Urban Environment (2022) is promoting their parks with a web page titled "Vihreät sylit" (English web page is titled Green Hearts) which translates to green laps, and by that they can promote an idea of being cherished by the greenery of their parks, which can be aimed at giving an experience of *ilinx* by feeling the satisfaction, happiness, and safety of being surrounded by green nature. In this example, the way to produce an experience of bodily feeling is quite different compared to the promoting approach of e-scooters companies that were reviewed earlier.

In addition to these four, Caillois and Meyer (2001) recognise that these four elements are not always in isolation, and can be observed in situations where some of the elements are united, and as distinct principles they would not likely mix indistinctly. Also, it is to be noted that there are more and less natural combinations, and because of this some of them can be mutually exclusive. Caillois and Meyer (2001) present examples of this with the combination of *agôn* and *ilinx* or *alea* and *mimicry* and call them "Forbidden Relationships". The point of Forbidden Relationships can be seen and accepted when the elements are examined with an absolute interpretation of the original definitions, and tried to combine as one experience arising from two. In gamification it could be argued that even elements of the Forbidden Relationships can be seen in the same solution, especially if they occur in different phases of the whole experience. As examples of this argument of forbidden relationships occurring during a whole experience, a person in a bicycle race (*agôn*) can be competitive but also enjoy the bodily feelings (*ilinx*) that high speed and skilful cycling offers, or a person performing tasks or quests with random outcome (*alea*) can be using those outcomes to enhance their avatar (*mimicry*).

## 3.2 Affordances

### 3.2.1 Gibson's affordances

A key factor for a successful gamified solution is its affordances. The originator of the term affordances in the context that it is used in this thesis is James J. Gibson (Gibson, 1977). James G. Greeno explained Gibson's meaning of affordances in his review called Gibson's Affordances to refer to "whatever it is about the environment that contributes to the kind of interaction that occurs" (Greeno, 1994).

Greeno (1994) sees affordance as an attribute of something in the environment in relation to the activity of a user who has some abilities, which fundamentally leads to the relation of abilities and affordances determining the outcome of the situation. In this idea,

the action by the user leads to desirable effects if the conditions by affordances are proper.

As an example of this, Greeno (1994) uses a situation where the action is to walk into the room, and the desirable effect is to be in the room. Affordances of this situation can include the presence of a doorway, and the doorway must be wide enough to walk through. In addition to the doorway, a needed affordance is the path to the doorway, which is enough strong to support the user to walk to the doorway. If the affordances of doorway and path are not fulfilled the outcome will not be desirable. Even if these affordances were proper, the outcome would not be desirable, if the path or doorway would have a large obstacle in the way to block the access to the room. Also, the user must have the ability to use these affordances. As an example, if the user cannot see or cannot walk, the affordances are then not proper, and the outcome will not be desirable.

To translate this example of walking into the room into the context of promoting sustainable transport modes with gamification the situation could be following. The action is to commute to work by bicycle and the desired outcome is to arrive to workplace with a bicycle without causing unsustainable emissions. The basic affordances in this example are proper infrastructure and a bicycle to use. The less obvious affordances are derived from the user's abilities. If the user lacks motivation or knowledge to perform the action, it can be supported with gamified solutions to the point where the user would be available to perform the action. And if the scope is broadened to the affordances of affordances the user must have capabilities and possibly needed devices to use the solution. If the gameful experiences are examined with a broadened scope, the infrastructure could also be engaging and enjoyable to the point where it motivates the user to perform the action. In addition to these affordances, other abilities might function as an obstacle for having the desired outcome, like the physical fitness of the person, but these affordances are not relevant for the example when examining from the thesis' point of view. Although, the gameful experience of guided might help the user, if they are affected with similar ability related problems. If the affordances are proper to the action to commute to work by bicycle, the effect can be desired, and the action performed.

Possible affordances that are interesting for the thesis and the framework to be built, are the affordances that enable the user to perform the action. By proper customer segmenting, the affordances of the affordances (e.g., needed devices and skills to use them) are taken care of. Also, the basic affordances that were mentioned earlier (e.g., vehicles, infrastructure, public transport network) would be assumed to be taken care of when examining the affordances within the framework.

Roughly the affordances that the framework are interested in are the different implementations of motivational affordances in gamified solutions (Hamari et al., 2014) and the experiences they produce, enhancements in the city environment, their amenities like parks, and augmentation of reality. Also, it is important to detect the intersections and synergies between the affordances, which support each other.

### **3.2.2 Motivational affordances in gamification**

In their literature review, Hamari et al. (2014) categorised studies about cases of gamification into categories in different ways and analysed them. One of these ways was to analyse motivational affordances in gamified solutions. The motivational affordance in this context is the implementation technique in the gamified solution which has been used to make the solution gameful.

From the literature that Hamari et al. (2014) conducted, the most often found motivational affordances were points, leaderboards, and badges or achievements. Other noticed motivational affordances were levels, story, clear goals, feedback, rewards, progress, and challenge. It is important to understand the difference between motivational affordance and gameful experience as they seem quite similar. The gameful experiences represent the feeling which occurs in the user, and the motivational affordance is something built into the solution. Although, motivational affordances and certain gameful experiences should not be separated, but instead see their synergic connection. As an example, if achievements are used as a motivational affordance, it would be quite self-explanatory that it will aim to gain the gameful experience of accomplishment. The function and the approach to use the framework will dictate how these connections will be used to ensure the best possible outcome of the evaluation.

### **3.2.3 Environment as an affordance**

When creating affordances for gameful experiences without the layer of games, a good environment can be one solution. A survey study by Chiesura (2004) examined the role of parks. The survey was conducted among visitors of an urban park in Amsterdam, The Netherlands. "To relax" was the most frequent motive to visit the park by appearing in 73 % of the answers, "To listen and observe nature" was in 54.5 % of the answers, and 32.2 % of the returned answers mentioned "To escape from the city" as their motive to visit the park. The motions experienced in the park were also surveyed from the answers to the question "Which feeling does nature evoke you?" and the most frequent emotion was "freedom" which was in 64 % of the answers. Other items of the emotions experienced were "unity with myself" (34 %), "unity with nature" (42 %), "luck" (33 %), "adventure" (19



%), and “happiness” (35 %) (Chiesura, 2004). Chiesura (2004) grouped themes from the open-ended questions. Open-ended answers that are interesting for the framework are under the dimension “amenity” which are “I can forget my daily worries”, “To step out from the routine of everyday”, and “I take a break from the stress of the city”. When examining the found motives, and emotions from the survey Chiesura (2004) conducted, they can be seen as affordances for dimensions of gameful experiences Högberg et al. (2019) used in the GAMEFULQUEST. The most obvious dimensions parks would support are immersion and playfulness. With quite liberal and extensive examination the connection to nature can be seen as a parallel to social experience if the human aspect of the dimension is removed.

The effect of environmental aspects with positive association found with physical activity can support this proposed effect of nature, even with a different approach to the subject. A literature review conducted by Humpel (2002) found that certain dimensions relating to accessibility to facilities, opportunities for activity, safety, and aesthetics found significant positive associations with physical activity in some of their dimension. Especially the dimensions concerning aesthetics are interesting for the framework, as they regard the quality of the environment, more than the location of the user relative to the land use of the area. Items under the dimension aesthetics with significant positive association with physical activity were “Neighbourhood friendly”, “Pleasant near home”, “Local area is attractive”, “Enjoyable scenery”, and “Living environment”. Considering that these items have a positive association with physical activity, it can be argued that they motivate people to be physically active, and by that they work as a motivational affordance.

If we examine the studies of Chiesura (2004) and Humpel (2002) from the perspective of answering the question “can environment work as an affordance to increase the motivation of user to perform the action”, it can be argued that the environment can be part of the gameful experience. The environment can produce an emotion which is very near to a gameful experience (Chiesura, 2004), or it can be the catalyst to excite the person to become physically active, which might lead to usage of the gameful service, and by that to perform the desired behaviour.

It is important to remember that as an affordance the direct connection to a gameful experience is not always needed if the item in question promotes or enables the gameful experience, in the same way as the path and the doorway help the user to enter the room in the example from Greeno (1994). The more indirect the connection is, the affordance becomes less relevant for the framework. After all, the most important factor for the framework concerning the affordances is to recognize the affordances that make the

gameful solution work, which can mean the platform of the gameful solution and its implementation technique, or the enhanced public space which can generate a gameful experience. Another way to enhance the public space in addition to the physical environment is the augmented reality solutions.

### **3.2.4 Augmented reality as an affordance**

Augmented reality allows the user to see the real world with a virtual layer of objects in it, and therefore supplements reality rather than replaces it (Azuma, 1997). Augmented reality follows three characteristics which are: combine real and virtual, is interactive in real-time, and is registered in three dimensions (Azuma, 1997).

Augmented reality needs devices to be performed. The main devices are displays, input devices, tracking, and computers (Carmigniani et al., 2011). Displays can be head-mounted displays (e.g., wearable goggles with see-through features), handheld displays (e.g., smartphones), and spatial displays (e.g., video-projector in a public setting) (Carmigniani et al., 2011). The input device is the device which is used to input the user actions, and the choice of input device depends on the type of application the system is being developed and the chosen display. Tracking devices consist of cameras, sensors, GPS, accelerometers, and other similar devices which can provide enough accurate data for the solution (Carmigniani et al., 2011). The most important factor for tracking devices is that they can tell the system the position and direction of the user with enough accuracy for the solution to work. The last device needed is a computer, which needs to be enough powerful to execute the needed software for the augmented reality solution (Carmigniani et al., 2011).

Probably the augmented reality solution which gained the most publicity and is the most well-known is the previously (in section 3.1.2) mentioned video game Pokémon Go. Pokémon Go uses GPS to match the position of the player in a real world with the map of the game, and when the Pokémon creature appears, the user uses their mobile phone to perform the action of “throwing the Poké Ball at the creature to catch them”, and by that they can try to fulfil one of the goals of the game (Paavilainen et al., 2017). Key drivers to enjoy playing Pokémon Go seem to be the social aspects, and the way it incorporates outdoor activities and exercise, in combination with the globally recognised brand of Pokémon (Paavilainen et al., 2017).

It was found that Pokémon Go increases physical activity regardless of age, gender, BMI levels, or prior activity level (Althoff et al., 2016). Compared to other mobile health apps, it was found that Pokémon Go led to larger increases in physical activity and attracted more users who were not very active yet (Althoff et al., 2016). Because Pokémon Go

can reach low-activity populations who also see the largest benefits from the increased activity, the promise of game-based solutions can be highlighted, as the more traditional approaches have often been more ineffective for people with low activity levels (Althoff et al., 2016). Althoff et al. (2016) noted that the big problem with realising the potential of Pokémon Go is about sustaining a long-term engagement in the game. For the sustained behaviour change to form, the user would be required to stay interested in the game. A notable limitation of the study was its follow-up period of 30 days, which restricted the examination of long-term effectiveness in increasing physical activity with games such as Pokémon Go (Althoff et al., 2016).

For the framework, Pokémon Go is an interesting case example of an augmented reality solution, which increased physical activity in a demographic that was not as interested in more traditional measures (e.g., regular fitness application). This trait of Pokémon Go is interesting, but it is important to notice that the success of Pokémon Go is exceptional. Thus, recreating the same level of success with promotional measures of sustainable transport modes will be hard. Nevertheless, the solution should be capable of gaining some sort of positive effects on physical activity, even without the global success of Pokémon Go. This is especially useful, if the effect can be aimed at a certain demography, which is not otherwise interested in the promotional measures, but can be motivated with alternatives like augmented reality.

### **3.3 Enhancing services**

#### **3.3.1 Introduction**

This section will examine examples where gamification has been used to enhance different services and functions. Examples that are examined in this chapter are enhanced education, health care, and crowdsourcing. These examples were chosen as they are quite straightforward in the way they used gamification, but in the context of using the framework, enhanced services might be any part of the service it is taking an effect on, no matter how vague or small part of the entirety of the service or system it is.

For the framework, these examples are important to understand what kind of enhancement opportunities gamification enables with different services. Although, as the variety of possibilities is very wide, it is impossible to examine examples of all the different possibilities. The design process of identifying the enhanced service and coming up with the way it will be enhanced may not be straightforward, and thus it needs a lot of attention as it is one of the core factors in the solution to decide if it will be successful or not.

### **3.3.2 Prediction market enhancing learning.**

Buckley and Doyle (2016) studied how gamified learning intervention affect learners. Online-based gamified learning intervention was built around a prediction market (PM). The concept of PM is to allow participants to activate “contracts” regarding future events, which leads to group forecasts about these events. As an example, a teacher could evaluate an assignment by making a contract about completing the assignment to a certain degree and post it on an online platform for the students to see. If a student would choose to activate the contract, they could get a return of one hundred currency or points if they succeed in the assignment, and zero points or currency otherwise. If many students activate this contract, the return will decrease, and if only a few activates it, the return will increase. This creates a market-driven group decision-making system, which rewards for correctly forecasting the contracts.

In the study Buckley and Doyle (2016) designed and deployed the PM as a part of an undergraduate module in taxation with a focus on developing skills in the calculation of tax liabilities. The PM learning intervention was developed to affect 10 % of a student's grade based on their performance in the PM. In the intervention, the PM was developed in a way where students would also learn the subject as they try to make informed and accurate forecasts of contracts. Students were provided with five thousand units of virtual currency when the PM market opened, and they could invest in outcomes that they considered the most likely for each question presented to them.

Results of the study supported parts of the presented hypothesis, although acknowledged limitations of the study should be considered in the evaluation. The study found that their gamified learning intervention improved students' general knowledge of the national tax system. Also, the study found that intrinsic motivation to know and identified motivation are positively correlated with participation, and intrinsic motivation has a correlation towards stimulation and participation. The demonstration of gamification's effect in the study is based on the stimulation gamified learning intervention provides with leaderboards and ranking systems, as well as the inherent uncertainty of forecasting. In summary, the study presents how gamified learning interventions have a positive impact on learning outcomes, and it is a powerful tool for educators teaching at all levels within the education system.

To put this study in the context of enhancing services, Buckley and Doyle (2016) created a gamified solution to support the core function of learning by creating stimulation, which excited students to learn more. The solution enhanced learning by supporting students'

motivation by providing gameful experiences through the affordance of a web-based solution and studying material, which was realised as a competition on a leaderboard that measured learning and success in the competition.

### **3.3.3 Pain Squad enhancing healthcare.**

A smartphone application called Pain Squad was developed to help with the problem of poorly managed pain for adolescents with cancer (Stinson et al., 2013). Pain Squad is an electronic pain diary which collects data about pain intensity, duration, location, and the impact pain has on an adolescent's life with twenty questions twice a day to evaluate the medication and pain management strategies for the patient. The application also had a function to alert the research team if the user's pain was moderate or severe for two consecutive entries. Gamification of Pain Squad is built upon acquired responses, as the application's story progressed, and the user earns promotions to increase their "rank", which also unlocked a short video and a medal to reward the users for answering the questionnaire prompts.

The study demonstrated a high rate of compliance in a 2-week clinical feasibility test (Stinson et al., 2013). A clinical feasibility test also showed that adolescents with cancer enjoyed using the application and experienced it as attractive and easy to use, which could be argued to have intrinsic value.

Pain Squad used gamification to enhance the service of logging in data about assessing pain. By adding achieving, immersion, and playfulness into the solution, logging data was more enjoyable, which probably supported the solid compliance rate. This enhancement benefits the users and the provider, by making the process more fun for the user, and allows the provider to receive more constant information to make as good as possible judgements for the user.

### **3.3.4 ParKing enhancing crowdsourcing.**

ParKing is a crowdsourcing system used on smartphones to gather data about on-street parking by sourcing it from the input by the users of the mobile phone application (Morschheuser et al., 2019). In the ParKing application users input location-based information, such as prices and restrictions about the on-street parking they encounter, and it is directly visualised in the map of the application for other users. Presenting and gathering the crowdsourced data is the core service of ParKing. The gamification aspect of ParKing is its way of rewarding users for providing data and confirming provided data by other users. Users are rewarded coins for these actions, which can be used for the main game mechanism of conquering virtual territories. With the coins earned, the user can

purchase street segments, and the user who owns most streets in the virtual territory is automatically the owner of it. After owning the virtual territory user can also use coins to create buildings in the virtual territory to show their superiority, and influence their gameplay (e.g., increased income, and value of their streets). The motivational affordance of this solution was the public showing of owned virtual territories, and counted points that were shown on a leaderboard.

The study found that the gamification probably affected the productive behaviour in the system by encouraging users to contribute more (Morschheuser et al., 2019). However, it was noted that competition was demotivating if it was unbalanced, and the user did not see a chance of winning or did not have enough strong competitors. It was noted that this negative effect of demotivation could be affected by having a team-based competition, thus utilising the best aspects of teamwork and co-operation in the solution with shared goals (Morschheuser et al., 2019).

To conclude, ParKing used gamification to enhance the core service of crowdsourcing. To do this they used leaderboard, scores, and virtual environment based playful and immerse simulation in creative ways so users can show their progress. This enhancement made the solution more motivating and enjoyable for users, which led to ParKing having confirmed data, and thus made the application better and more informative, and enabled the positive loop of bettering the solution to continue.

## **3.4 Motivation support**

### **3.4.1 Fogg Behavior Model (FBM)**

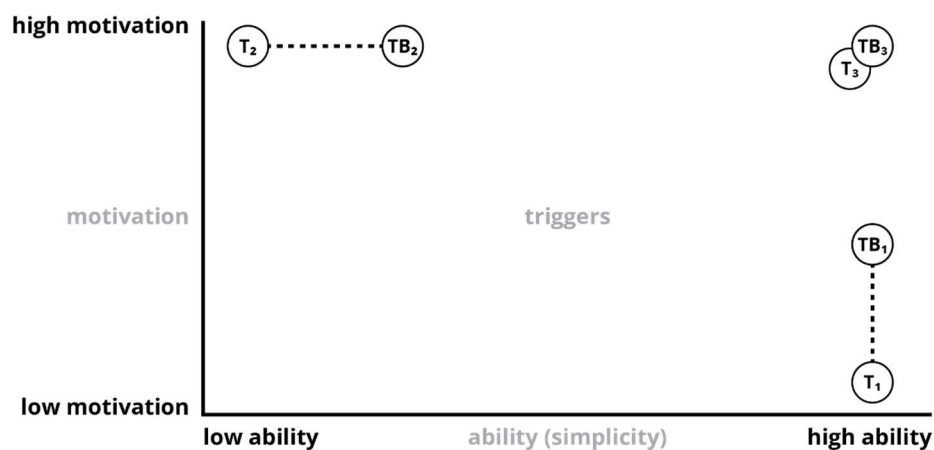
Fogg Behavior Model (FBM) is a model developed by BJ Fogg (2009). The purpose of FBM is to help researchers and designers think more clearly about behaviour, by using the framework of the model to examine persuasive designs in different settings, and to see new potentials for persuading users. Another use for FBM is to identify problems in persuasive systems, which fail to achieve desired outcomes. For better communication in various kinds of project teams, FBM offers a platform to create a shared frame of reference for people to ensure that everyone is thinking about behaviour changes in a similar way.

Three principal factors in FBM are motivation, ability, and triggers (Fogg, 2009). In Figure 7 these factors are visualised. The vertical axis presents motivation. The horizontal axis presents ability. Figure 7 also presents triggers and target behaviours in certain examples.

FBM is based on the trade-off between motivation and ability (Fogg, 2009). These factors among triggers to perform the behaviour should be aligned enough well to persuade the user to perform the target behaviour.

Fogg (2009) included three core motivators in the framework which were: Pleasure/Pain, Hope/Fear, and Social Acceptance/Rejection. For abilities, Fogg (2009) listed items called simplicity factors: Time, Money, Physical Effort, Brain Cycles, Social Deviance, and Non-Routine.

The third factor of FBM is the three triggers (visualised in Figure 7) which are spark ( $T_1$ ), facilitator ( $T_2$ ), and signal ( $T_3$ ). Triggers are prompts, cues, calls to action, and other ways to let the user know to perform the behaviour. Spark is a trigger that motivates a person, facilitator eases the behaviour, and signal is a reminder (Fogg, 2009).



*Figure 7. Revision of FBM visualisation inspired by the original figure by Fogg (2009)*

### 3.4.2 Interpreting GAMEFULQUEST and principals of FBM

In this chapter, FBM (Fogg, 2009) is interpreted with the dimensions of GAMEFULQUEST (Högberg et al., 2019). The goal of this is to find the linkages between these frameworks to recognise how gameful experiences could enhance the persuasiveness in promotional measures that are interesting for the framework.

Item Pleasure/Pain arises from a primitive response which happens immediately or nearly immediately when people respond to what is happening at the moment. Fogg (2009) points out that they are powerful motivators, but they are possibly not ideal, especially pain, but it is an option worthwhile acknowledging when reviewing motivations. Pleasure or pain could be linked with the GAMEFULQUEST (Högberg et al., 2019) dimensions playfulness, immersion, accomplishment, competition, and challenge.

Item Hope/Fear is characterised by the anticipation of an outcome (Fogg, 2009). Hope is the anticipation of something good, and fear is the anticipation of something bad. Hope and fear could be linked with GAMEFULQUEST (Högberg et al., 2019) dimensions accomplishment, challenge, competition, and social experience.

The third item is Social Acceptance/Rejection. The strength of this item arises from the effects our social behaviour has, and how we naturally want to win social acceptance and avoid being socially rejected (Fogg, 2009). Social acceptance and rejection could be linked with the GAMEFULQUEST (Högberg et al., 2019) dimension social experience. Social acceptance and rejection are hard to fit into other GAMEFULQUEST dimensions. In general, the effect of social acceptance and rejection relies on the social groups and peers, demographic factors, and the environment the person is in (Wentzel, 1994). Because of this, the examination of motivations related to social acceptance and rejection relies on the understanding of the target group and segmentation which the solution is aimed at.

Simplicity factors evaluate the ability of the user and are unique for each individual (Fogg, 2009). When planning gamified solutions, it is important to understand the common simplicity factors for the target segment.

Simplicity factors Time, Money and Physical Effort are quite similar as their impact on ability is heavily based on the life of the user and can hardly be impacted (Fogg, 2009). From the dimensions of GAMEFULQUEST (Högberg et al., 2019) guided is probably the most effective dimension, because the user can be guided in some situations to perform the behaviour despite their personal situation. A gameful solution could guide the user to perform the behaviour with minimal or completely without money, with effective time consumption or along with time-consuming tasks, or with a lower need for physical effort in a way that optimally leads to an outcome where the physical capability of the user improves.

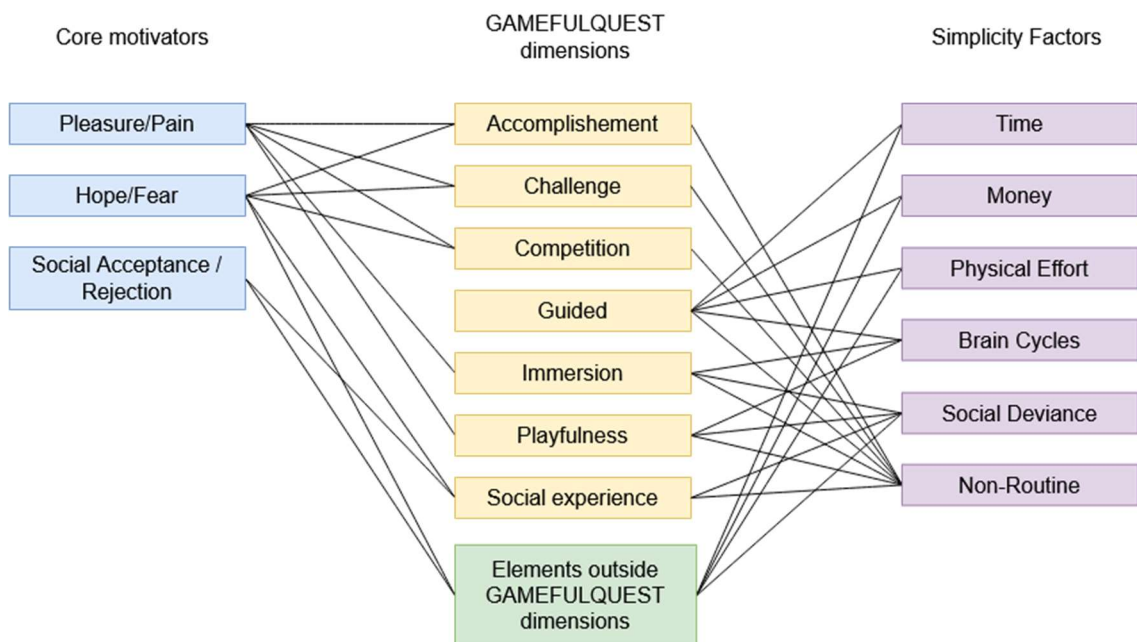
Brain Cycles is a simplicity factor which arises if the behaviour causes the user to think hard as the behaviour is not simple for the user, which is aggravated if the mind of the user is already consumed with other issues (Fogg, 2009). For Brain Cycles, the GAMEFULQUEST (Högberg et al., 2019) dimensions that could be considered are immersion, playfulness, and guided, as they have the ability to ease the thinking process or take the mind of the user away from other issues that they are consumed with.

Social Deviance is based on the behaviour that demands the user to act against the norm, and break the rules of society, which makes the behaviour less simple and hurts the simplicity of the behaviour (Fogg, 2009). Social Deviance is naturally very close to



the core motivation Social Acceptance/Rejection, and because of that it is linked to the GAMEFULQUEST (Högberg et al., 2019) dimension social experience as well as the elements outside gameful experiences, which were explained along the Social Acceptance/Rejection. Dimensions differentiating Social Deviance from Social Acceptance/Rejection are playfulness and immersion as they could influence a change to the rules based on the social norm, and by that make it less of a challenge to be socially deviant in the situation.

The last simplicity factor is Non-Routine, which is about the daily routine of the user and how they tend to do the same activities again and again (Fogg, 2009). Non-Routine can be fitted to all dimensions of GAMEFULQUEST (Högberg et al., 2019), as all of the dimensions can help the user break their habits and adopt new habits.



**Figure 8.** Linkages of core motivators and simplicity factors of FBM (Fogg, 2009) with dimensions of GAMEFULQUEST (Högberg et al., 2019)

Spark trigger is necessary if the ability of the person is good enough to perform the behaviour, but the motivation is not good enough to perform the behaviour. As an example, a person is not motivated enough to use a bicycle on their commute to work, even if they have time, and are capable of the physical effort, it is socially normal, and it is otherwise simple for the user. At this moment person is at point  $T_1$  in Figure 7. Then the user hears about the benefits of cycling for the person themselves and environment around them, and talks about these benefits to the social groups of the person, which leads to them starting

a cycle to work campaign. Now the trigger of finding out about the benefits of cycling has improved the core motivations of hope, social acceptance, and pleasure in the person, and their motivation has raised to the level of performing the target behaviour (TB<sub>1</sub>).

Facilitator trigger is necessary if the motivation is high, but the user lacks in ability. In the example for facilitator trigger, the person has moved to a new city and wants to use the local public transport system. Their motivation to use the local public transport system is high, as the person does not enjoy driving a car, and their social groups are generally against using a personal car. Nevertheless, the person is new in the city and does not know how the public transport system works, which leads to the person needing to do a lot of thinking to use the public transport, breaking the routine they already have, and a lot of time to learn the new system. At this moment person is at point T<sub>2</sub> in Figure 7. Then the person hears about a mobile phone application, which guides the user with usage of the local public transport system, and even has a playful interface to teach about the common procedures of using the public transport systems, such as how to purchase a ticket and which vehicles need to be called to stop at the public transport platform. Since the application raised the ability of the person, they start to perform the target behaviour (TB<sub>2</sub>).

Signal is the third trigger which is used when the motivation and ability of the user are enough high for the target behaviour. The signal is just a reminder for the person to perform the target behaviour. As an example, the person has the ability and the motivation to use a bus to commute to work (T<sub>3</sub>). The user gets a reminder from the public transport mobile phone application which tells them to leave their home to catch the bus, which leads the motivated user with a good ability to perform the behaviour after being reminded (TB<sub>3</sub>). Signal can be just the natural feeling of doing something, especially if the behaviour is a routine action for the person.

### **3.4.3 Behaviour change support systems**

A behaviour change support system (BCSS) is a system with psychological and behavioural outcomes designed to form, alter or reinforce attitudes, behaviours or an act of complying (Oinas-Kukkonen, 2013). To help design and research, Oinas-Kukkonen (2013) created a framework called O/C matrix (Table 3), which represents the combinations of outcomes and changes. Because O/C matrix is an accessible tool to use and explains the different approaches to behaviour change appropriately, it was chosen to be used in the framework of this thesis.

Oinas-Kukkonen (2013) describes the items of O/C matrix followingly. Forming (F-outcome) is an outcome where an act of complying, behaviour, or attitude formulates for a

situation or issue, which had no pattern of behaviour earlier. Altering (A-outcome) is an outcome which changes an existing act of complying, behaviour, or attitude to certain situations or issues. Reinforce (R-outcome) is an outcome where an existing act of complying, behaviour, or attitude has been reinforced to be stronger and more resistant to a change. The goal of complying change (C-change) is to make the end-user comply with a request or trigger of some sort, leading to a behaviour change called act of complying. Behaviour change (B-change) aims to create a more enduring change compared to compliance which is irregular or short-term. B-change primarily aims to create a long-term behaviour change, but one-time behaviour can be valuable, as it may be repeated in a way that results in ongoing exercise or obligation, and with sufficient time a long-term behaviour might be formed. Attitude change (A-change) tries to influence the attitude towards the behaviour instead of affecting the behaviour only.

**Table 3.** O/C matrix (Oinas-Kukkonen, 2013)

Outcome/Change matrix		Change		
		Act of complying (C )	Behaviour (B)	Attitude (A)
Outcome	Form (F)	Forming an act of complying (F/C)	Forming a behaviour (F/B)	Forming an attitude (F/A)
	Alter (A)	Altering an act of complying (A/C)	Altering a behaviour (A/B)	Altering an attitude (A/A)
	Reinforce (R )	Reinforcing an act of complying (R/C)	Reinforcing a behaviour (R/B)	Reinforcing an attitude (R/A)

Different combinations of outcomes and changes can be chosen to be aimed when designing persuasive systems in gamified solutions. If needed, combinations can be chained to achieve wanted end results.

As there are many different options, it is complicated to thoroughly explain all of these combinations and combination chains. As an example of this complicated manner, the chain of different outcomes and change combinations could be following. The user forms an act of complying (F/C) to some provided trigger in a behaviour that the user has no existing experience with. After complying to these triggers for a while, complying could form as a behaviour (F/B) as a long-term habit. After a while it might be necessary to reinforce this behaviour (R/B), to make sure that the behaviour is continuous and does not decline back to the undesirable earlier behaviour models.

In another example, the user might have attitudinal problems with the desirable behaviour resulting in the current behaviour being undesired, and in this situation the solution

aims to alter an attitude (A/A). After the attitude is altered, a behaviour could be aimed to be altered next (B/A) towards the desired behaviour.

BCSS and O/C-matrix can be used in multiple ways as a tool in the design process to find out the wanted behavioural changes that the designed solution is aiming to support. The goal of BCSS is inherently to be transformative, by attempting to cause a cognitive and/or an emotional change in the user's current state of mind into another planned state to cause behavioural changes (Oinas-Kukkonen, 2013). The usefulness of this system is in its opportunity to demonstrate the needs and aims of the solution in a way that allows an easy way to communicate them to everyone in the project, and by that enables a design for the commissioned solution which can fulfil its goals and meaning in the transport system.

### **3.5 Value creation**

The value gamified solutions create is formed from the end result, or during the use of it. Value is often created for the user, as it may often also co-benefit the service provider. Especially if the service is dependent on the scale and number of users, the value created will be co-beneficial, and in the best-case scenario it could allow the positive loop of a snowball effect which could create value for the user and the service provider.

The importance of value creation arises in the design process, as it is the core thing to consider when designing a gamified solution. Before knowing what the desired value to be created with the gamified solution is, the design process is practically impossible.

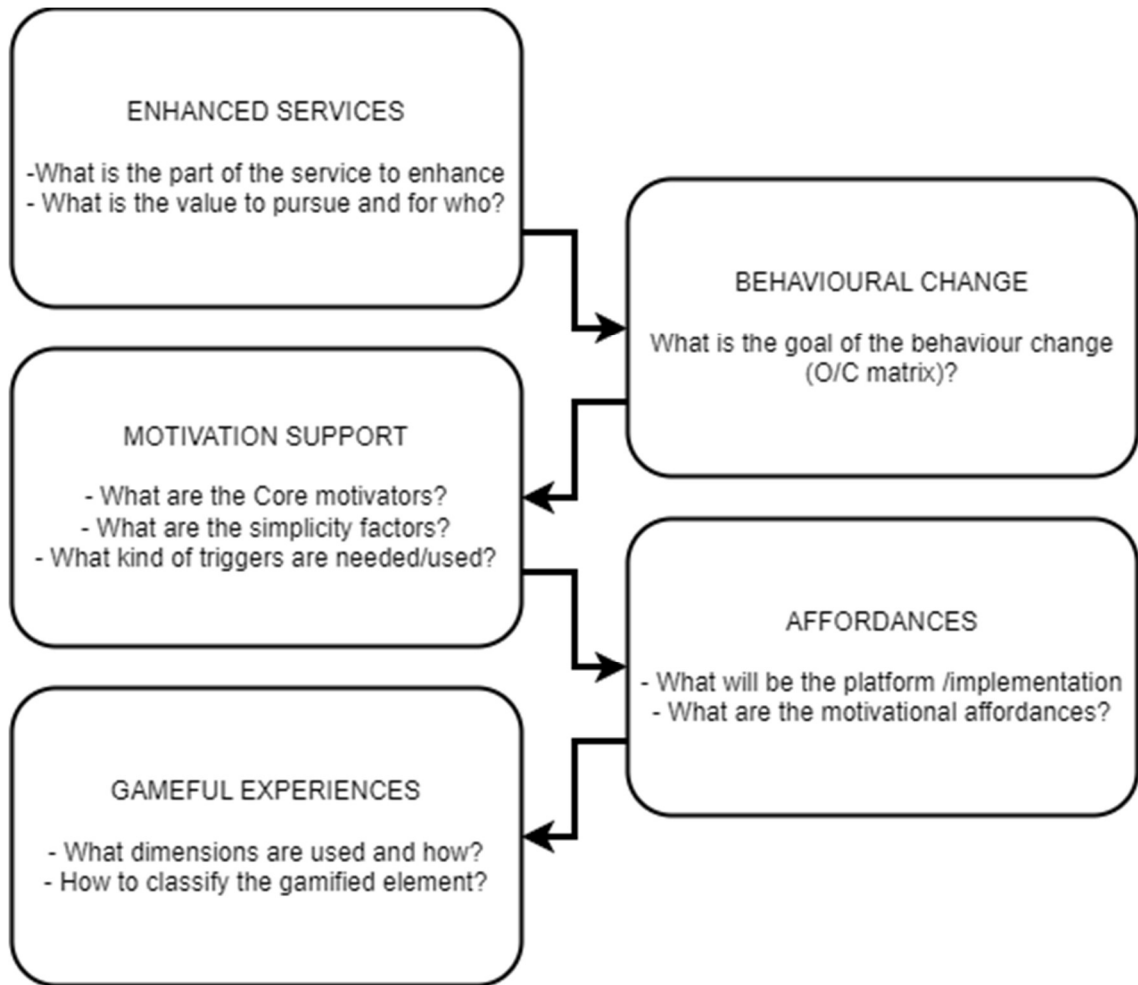
The created value can vary. As an example, the created value can be increased user satisfaction, user retention, or user activity with the solution. In addition to these examples, the created value can be anything important for the solution and the service provider, which is important to figure out to enable the solution to reach its goals.

## 4. FRAMEWORK AND EVALUATION OF THE CASE STUDIES

### 4.1 Framework

The framework was built from the findings of sections 3.1, 3.2, 3.3, 3.4, and 3.5. Key findings from these sections were combined into the framework that consist of five logical steps to evaluate gamefulness of different solutions. The included steps are enhanced services, behavioural change, motivation support, affordances, and gameful experiences. After examining these steps, it should be possible to compile some level of understanding about the gamefulness of the solution.

In enhanced services step, the solution will be examined by investigating the part of the service which will be enhanced, the value that the enhanced service will create, and for whom it will be created. In the behavioural change step, the type of behavioural change that the solution is aiming at will be investigated using the O/C-matrix (presented in Table 3). In the third step we examine the solution's motivation support, by investigating what kind of core motivators and simplicity factors are present with the solution and what sort of triggers will be used or are needed to initiate the behaviour. After this, in the affordances step the solution's implementation, and what sort of platform it uses is examined, and based on that information the used motivational affordances will be investigated. In the last step called gameful experiences, we will use the information gathered in the earlier steps to find out what gameful dimensions (presented in Table 1) are used, and how the gamified elements could be classified (presented in Table 2).



*Figure 9. Framework to evaluate solutions.*

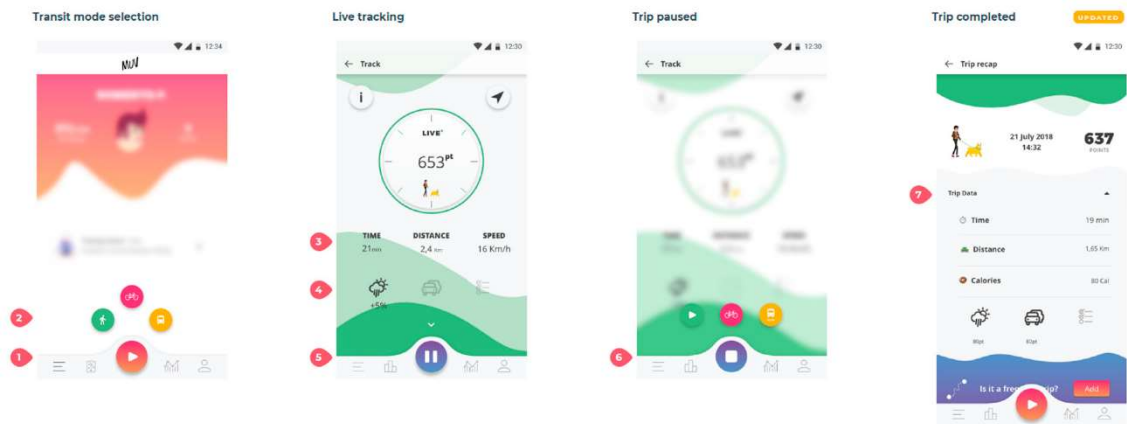
## 4.2 Case studies

In this section, the framework presented in section 4.1 will be used to evaluate different case studies. Case studies were chosen to represent different kinds of solutions in the field of transport. Some of them were gamified on purpose, and some were not. The aim is to find out how well the framework can be used as a tool to evaluate solutions. The reason to choose solutions that are different from each other is to see how viable and flexible the framework is. Methodology of this the selection was explained in chapter 2.4.

The evaluation's aim is to build a conclusion about the solution's gamified nature, if there is any, and how it is used to gain value. Also, the framework can be used similarly to evaluate ideas about gamifying solutions. The linkage to solutions promoting sustainable transport modes lies within the possibilities given to transport professionals to design and commission gamified solutions for which the framework can offer in an easy-to-understand form.

### 4.2.1 MUV Game

MUV game was developed as a part of Mobility Urban Values (MUV) project (European Commission, n.d.). MUV was a project funded by EU, and the project was active in multiple countries between years 2017 and 2020 (European Commission, n.d.). Main goal of MUV was to reduce urban traffic with novel approach to behaviour change towards more sustainable and healthy mobility choices. The MUV game was designed to affect intrinsic motivations with the gameplay mechanic of letting the player to collect points by playing the game by using sustainable modes of transport to allow them to level up and gain access to new game scenarios (Di Dio et al., 2019). MUV game also includes virtual badges, avatar customisation, discounts and gifts, and social aspects (Di Dio et al., 2019). MUV game is evaluated with the framework with information compiled from the websites (MUV B Corp, 2023), articles (Caroleo et al., 2019; Di Dio et al., 2020, 2019), and other documents (European Commission, n.d.).



**Figure 10.** Screenshots of MUV game's mobile phone application (Caroleo et al., 2019)

MUV game is a standalone game, and as such it does not directly enhance any other service directly. The service that MUV game enhances is the transport system in general as it tries to encourage people to make more sustainable transport choices. The pursued value is generated from the benefits of increase in the usage of sustainable transport modes. Other pursued value is generated for the users as their travel will be more enjoyable and fun as it has gameful elements. Also, it may have an ability to introduce or encourage people to try to use more sustainable modes of transport on their different travels.

Behavioural change that MUV game is trying to create could be evaluated in many different Outcome/Change matrix combinations. Depending on the user, the outcome can

be either form, alter, or reinforce. MUV game can help the user to form new habits and alter their old ones in similar ways as the encouragement provided by gameful elements. In a similar way the gameful elements have the potential to reinforce already established habits and potentially encourage the user to perform the behaviour more often or hold on to the habit. The change that MUV game provides to the user is often targeted to their behaviour. Other change in some situations can be the attitude change if it is formed or altered because of increased usage of sustainable transport modes.

The motivation support is heavily based on the factors based on competition that the game offers. Core motivators used are pleasure/pain and hope/fear that arises from the competition based on the points scoring and competition over the leaderboard. Social acceptance/rejection might be a core motivator if the game is played with a social group such as a work group or other kind of a social circle. Simplicity factors affecting the use of the MUV game depend on the user and their location. Probably the most usual simplicity factors for the user are time, money, physical effort, and routines. The trigger that MUV game provides is spark, as it provides users motivation to perform the target behaviour. Prediction about the susceptibility of user to perform the target behaviour is based on the user's level of ability from the simplicity factors and how they perceive the strength of the core motivators that the MUV game offers.

As a mobile phone game, it is natural that the user's phone and the availability of means of travel are the most important core affordances to use the service. The importance of these affordances lay on the fact that the service is unusable if the potential user does not have them. The quality of mobile phone or availability of the means of travel can prevent person from becoming a user of the MUV game because every phone is not capable of running the software, and lack of transport options (e.g., cycling infrastructure or public transport) make it impossible to play the game in the way it is designed to be played. The motivational affordances with the MUV game are related to the competition like points, tournaments, goals, and leaderboards. These competitive motivational affordances try to keep hold of the user to ensure that they are engaged with the game, and that it works as an enjoyable solution to increase the probability of performing the target behaviour, which in this situation is the increased usage of sustainable modes of transport.

The MUV game would most logically be classified as a mixture of *ludus* and *agôn* as it consists of competition that is tied to rules and a system of provided by the game, and because of this the solution does not really have any leeway towards *paidia*, if as an example playfulness does not arise internally from the person themselves. Also, in some

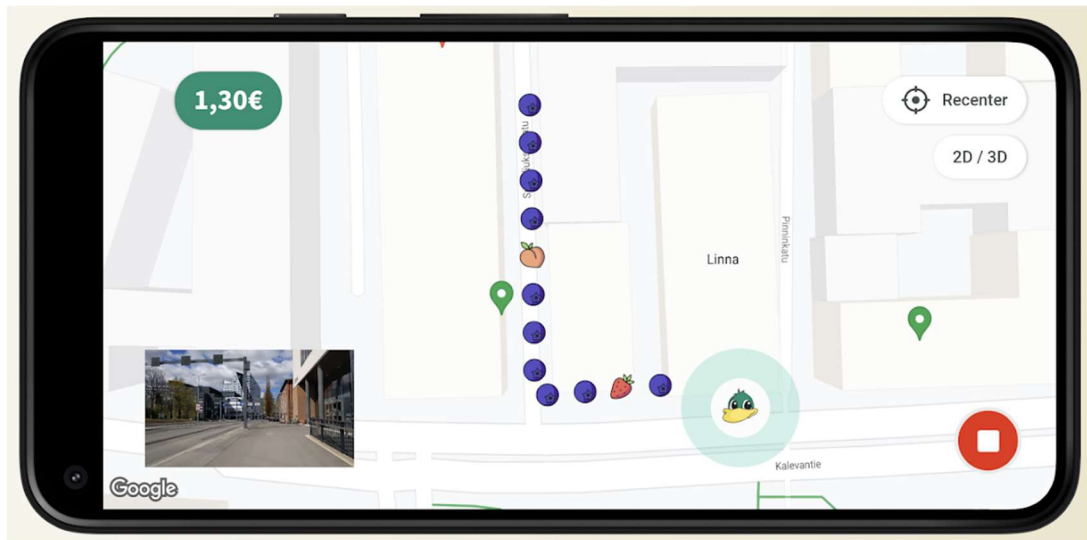


situations MUV game might have some number of elements linked to *mimicry* if the tournament encourages the users to work as a team linked to some sort of identity. An example of this could be a tournament where fans of football teams competed against each other in the game as a parallel competition to the real-life football games. The most obvious GAMEFULQUEST dimensions that can be found from the MUV game are accomplishment, challenge, and competition, as they are built in the core idea of the solution. Other dimensions that could be applicable to the solution are immersion and social experience. Social experience can be felt if the user is communicating or feels like they are communicating in some sense with the other players or their friends who also play the MUV game. Immersion might be felt if the user is enough motivated and invested in the game to focus their attention in a manner that results to change in their perception of their surroundings, leading to them ignoring the world around them, and time passing more quickly.

After evaluating the MUV game using the steps assembled in the framework, gamified elements of the mobile phone application are obvious because it is an actual game. With the aim of changing travel behaviour, MUV game has a chance to use its gameful nature to engage people and retain their behaviour, in a way that has the potential affect users' habits. MUV game has already shown some potential to be a promising tool to move people towards more sustainable modal choices, and to involve citizens with policies affecting the development of environmentally sustainable cities (Di Dio et al., 2020).

#### **4.2.2 Crowdsorsa**

Crowdsorsa is a crowdsourcing mobile phone application, that specialises in data collection on the infrastructure sector (Crowdsorsa, 2023a). Crowdsorsa encourages citizens to drive their bicycle or a car and collect different kinds of “berries” that are placed on the streets of the surveyed area, while the user film their journey on their mobile phones. Different “berries” have their own values, which builds up the monetary value that will be rewarded to the user collecting them, after the user has uploaded a proper video of the area to Crowdsorsa service to be analysed and used for information such as road condition or asset maintenance (e.g., condition of trash cans or park benches). In the business model of Crowdsorsa cities and municipalities commission data from Crowdsorsa, and Crowdsorsa takes care of the implementation and analysis of the data, in a way that they describe fast, cost-cutting, effortless, and participatory for the citizens (Crowdsorsa, 2023b).



**Figure 11.** Screenshot of Crowdsorsa mobile phone application when the user is collecting data (Google, 2023)

Since Crowdsorsa is a stand-alone game, it does not enhance any other service directly. Value of the service is produced externally for the users, and the customer of Crowdsorsa. Firstly, the user of the Crowdsorsa application is awarded with money from the “berries” they have collected, and possible feelings of succession from the competitive aspects built with leaderboards in the application. After this, the customer of Crowdsorsa receives needed data to enhance and upkeep their infrastructure, thus enhancing the infrastructure that the customer is responsible for, which translates to enhancement of external services of the city or municipality. From transport perspective this is important as Crowdsorsa does not naturally focus on strictly changing transport habits, but rather encourages recreational cycling and driving, which leads to enhanced infrastructure. Enhanced infrastructure is important, as it hopefully transforms into changes in the transport system and provides value for the user and the customer.

Behaviour changes to evaluate are formed as changes in recreational cycling and better infrastructure. The encouragement of recreational cycling can lead to form or reinforce a behaviour of cycling. Better infrastructure can lead to form, alter, or reinforcement of behaviours or attitudes depending on the user, but these behaviour changes could also happen to the other residents of the area as an effect of improved and well-maintained infrastructure.

Motivation support of Crowdsorsa mostly arises from the core motivators of pleasure/pain and hope/fear linked to the monetary awards and feelings of accomplishment, challenge, and competition of being successful in the leaderboard of the event. Simplicity factors of Crowdsorsa are harder to specify but probably the most often occurring simplicity factors are brain cycles and non-routine of taking part in a crowdsourcing event,

but also money from the chance of monetary awards might be viable simplicity factor, as it turns the cost of transport into profit. Crowdsorsa's service can function as a spark, facilitator, or signal trigger depending on the user, and the user's motivation or ability to collect the "berries".

Affordances for Crowdsorsa are quite simple. Crowdsorsa is implemented as a mobile phone application, and it is the only way to take part in it. Because of this, a mobile phone is needed for the user, but in addition the user's mobile phone must have proper components and features to be able to record the video with the required quality for the service. Also, the user needs the vehicle and some sort of phone stand to record the video.

Crowdsorsa can be quite easily classified as a combination of *ludus* and *agôn*. Sometimes *alea* could also be connected to Crowdsorsa's usage and the chance of monetary awards. Gameful experiences that Crowdsorsa produces could be described with dimensions of accomplishment, challenge, and competition. Accomplishment arising from ranking high on leaderboard, collecting "berries", and monetary awards is probably the most evident of these dimensions.

As a summary of the evaluation, in Crowdsorsa the gamified elements are obvious as it is an actual game. Crowdsorsa can encourage people to cycle recreationally and offer municipalities important data about their infrastructure property by offering monetary awards to users as a motivation. Even if encouragement towards recreational cycling may not be the most important change in a transport system, the external value gained from improved maintenance of infrastructure should yield positive effects in transport system. Thus, Crowdsorsa is an example of gamified solution that is beneficial for the transport system from an external point of view. Also, this sort of motivating through monetary awards kind of approach could be applied in a different setting and solution in a way that could encourage behavioural changes towards sustainable transport modes in general and more directly.

#### **4.2.3 Workplace competition to promote commuting with bicycle.**

Workplace competitions are quite common way to promote commuting with sustainable modes of transport such as cycling. Thus, these workplace competitions are analysed as a general phenomenon, since they tend to have the same principle of competing against or with your workmates to gain the highest points for the distance or frequency of commuting with a sustainable mode of transport, and the person or group with the

highest points being rewarded with something. For these workplace commuting competitions, abbreviation WCC will be used in this section. In this case study. We will assume that the goal of WCC is to promote cycling and usage of public transport for commuting, thus it will be the behaviour to promote.

The service that WCCs enhance could be broadly interpreted to be the work life in the company. More directly, it should enhance the commuting, wellbeing, and enjoyment of the working life. These areas of enhancement are beneficial to both employee and employer. Employer benefits as the increase in commuting with public transport leads to decrease in the office's need of parking spots (Sælensminde, 2004), and lower greenhouse gas emissions, and in addition to the previous, commute with bicycle also has health benefits that can lead to decrease in sick leaves (Hendriksen et al., 2010), and improvement in general for the productivity of the employee as a result of better health and enjoyment of the workplace atmosphere (Stewart, 2003). Employee benefits from the system by potentially having fun, interesting, and social activities and the chance of being awarded, which could lead to motivate them to healthier lifestyle choices, new ways of being social in the work group, and maybe even to form new habits.

The behavioural change that WCCs aim at often are to alter or form behaviours, which may work as a reinforcement for those who are already engaged in the desired behaviour. Optimally, after the behaviour has been altered or formed, the potential longevity of the WCC is used to reinforce behaviours. If the WCC would be successful there is also an opportunity to form or reinforce attitudes of the participating users.

As the WCC is conducted in a workplace group, social acceptance and rejection arises as an important core motivator along with hope and fear of the rewards, and pleasure or pain for the physical effort and external conditions such as weather or facilities. Simplicity factors that have a role with WCC are social deviance and money as positive factors, and physical effort and time as potentially and more likely negative factors, that could also be positive in the right circumstances.

Affordances for a WCC are varied as the competition can be held in different sorts of arrangements. The main core affordance could be to have an office in a location where it is possible to commute with sustainable transport modes, and even better if these modes of transport have the possibility to be competitive against the usage of a personal car. Other affordance could be to have enough communication channels to engage employees in the action and to have someone able to organise the WCC. Third important affordance is to ensure that the employees have access to a bicycle or public transport

tickets. These can be eased if the company is ready to offer a bicycle or a public transport ticket to the employee so they can join the WCC with no barriers of entry.

WCCs are most often classified as *ludus*, or at least leaning towards *ludus*, because of the controlled and rule-based point calculation and score keeping. Depending on the rules of the WCC, it could be classified as *agôn*, *alea*, or *mimicry*. *Agôn* is practically always part of the WCC, *alea* can be relevant if the WCC is using raffle like elements, and *mimicry* might be a part of the WCC if team identities, or other kinds of role-playing elements are implemented in the WCC. Gameful dimensions that are relevant with WCC are competition, accomplishment, and challenge. Also, social experience is important, especially because of the social circles of the workplace that are related to the WCC. In some circumstances guided might also be a relevant dimension if other dimensions are enough strong to encourage a person without needed ability to try sustainable commuting, and the WCC is enough supportive to help them to form a new habit.

WCC is a classic cycling promotion measure known in many communities, and it is one of the well-known ways of influencing commuting habits with methods that are close and align with multiple gameful dimensions. Different kinds of WCC have been found effectful and functional as an intervention to form and alter commuting behaviours (Millonig et al., 2016; Uttley and Lovelace, 2016). It could be argued that the effect on commuting behaviour is impactful as it affects the everyday transport, and thus it has the potential to scale up and have a meaningful impact on the development of more sustainable transport habits in the company, and to have healthier employees as the effect of increased cycling. These positive consequences can be seen as a result of using gamification as a tool to enhance a commuting intervention.

#### **4.2.4 CitiCAP**

In this section CitiCAP project that was implemented in Lahti, Finland in the year 2020 will be reviewed (City of Lahti, 2021a). CitiCAP was funded by the EU's Urban Innovative Actions initiative. CitiCAP was a personal carbon trading pilot, with the main goal of encouraging citizens to make sustainable mobility choices by rewarding them through the developed mobile phone application which can recognise the mode of transport that is being used. Users would gain virtual euros for having lower personal emissions than the given personal emission gap which was set based on user's situation in life. Earned virtual euros were available to be used in the marketplace of the mobile phone application for various products and services.



**Figure 12.** Page in CitiCAP mobile phone application where the user can see information such as, their previous trips, produced CO<sup>2</sup> and the target for the week, and earned virtual currency. (City of Lahti, n.d.)

The service that is enhanced with CitiCAP is the transport system of Lahti in general, and the sustainable urban mobility plan that was updated around the same time as the application was developed. For users, the enhanced part of the service, and the value to pursue with CitiCAP was the monetary gain achieved by using sustainable modes of transport. For the city of Lahti, the pursued value was the increased usage of sustainable modes transport, which contributed to the goals of Lahti considering carbon neutrality by 2025, and sustainable transport modal share by 2030 (City of Lahti, 2020). Also, it could be argued that the citizen engagement related to the development of the application is a positive outcome for the city of Lahti.

Behavioural changes connected to CitiCAP are varied, as they can cover form, alter, and reinforce outcomes depending on the user's starting point. CitiCAP is not using the act of complying, thus the changes it can facilitate are to behaviour and attitude. Probably the strongest effect in a system such as CitiCAP is around reinforcing behaviour, as the

users that are already performing the desired behaviour are now receiving benefits for continuing to perform the behaviour connected to the already established habit.

The core motivator for CitiCAP is the hope/fear of being awarded with virtual euros. Also, social acceptance/rejection could be a motivator if there are social interactions connected to the usage of CitiCAP (e.g., if a friend group is using it together). CitiCAP could be connected to simplicity factors money, physical effort, and time. CitiCAP tries to use the possible monetary gains as a core motivator to produce spark factor, to increase the motivation of the user who already has the needed ability to perform the desired behaviour but is not enough motivated to perform it.

CitiCAP works as a mobile phone application, and because of that mobile phone is a necessary affordance. Because the pilot was based on Lahti, it could be assumed that the environmental affordances such as the infrastructure are existing. Motivational affordances to use CitiCAP are to gain and use virtual euros, and possibly the feeling of participation in new solutions regarding sustainable transport, if that is something that is aligned with the values of an individual user.

CitiCAP's gamefulness could be described with the dimensions of *ludus* and *alea*, as the gamefulness is completely and strictly based on the rules of the game, and with the chance of achieving virtual euros. Accomplishment arising from earning virtual euros is the straightforward gameful dimension that can be linked to CitiCAP, other dimensions such as social experience, competition, or guided may be connected to CitiCAP in special circumstances where the social environment or the user's existing habits allows them to experience these gameful dimensions.

As a conclusion, CitiCAP can be described as a gameful solution to enhance usage of sustainable modes of transport. Although, through the analysis it could be noted that the gamefulness of CitiCAP seemed to be quite limited to the chance of monetary gains from virtual euros, and other dimensions were tied to different independent contexts. Despite this, the concluding report of the pilot found that CitiCAP grew interest towards reducing personal emission. 70% of the respondents of their survey found that personal carbon trade was a fair way to reduce emissions in the society, and 36% of the respondents reduced their mobility emissions (City of Lahti, 2021b).

#### **4.2.5 Cities in general**

As the last case study, the gamefulness of cities will be contemplated. Because cities around the world are quite different to each other and unique, in this section we will focus on aspects and attributes of cities that are seen as walkable and lively. These aspects



and attributes might consider the way we design streets and areas as well as the zoning decisions, and how different functions such as public places or transport hubs are implemented in our cities. To get a better understanding about the sort of cities that are considered in this evaluation see the reference pictures (Figure 13, Figure 14, Figure 15, and, Figure 16).



**Figure 13.** *A visually stimulative street in Belfast, Northern Ireland (Photo: Sjögren, 2023)*





**Figure 14.** *A pedestrian street with greenery that guides and is visually attractive in Malmö, Sweden (Photo: Sjögren, 2022)*



**Figure 15.** *A socially active riverfront with a lot of activities in Prague, Czech Republic (Photo: Sjögren, 2022)*



**Figure 16.** *An intriguing residential street with short sight distance that draws the pedestrian to explore corner after corner in Rethymno, Greece (Photo: Sjögren, 2022)*

If these walkable cities would be gameful, what parts of the service would be enhanced? This question insists that the cities are seen as a service, which is the needed starting point for the evaluation. This point of view could be observed by interpreting cities as a service that the municipality offers to the citizens as a critical infrastructure to live their lives as a functioning human that can use a wide variety of offered services ranging from stores, restaurants, and such to the public spaces such as parks and squares where citizens can spend their time. This critical infrastructure is the part of the service that is enhanced by creating and maintaining walkable cities. Value of this enhancement is created to the citizens as their living environment would be more enjoyable, which can lead to an increase in the number of customers visiting businesses, citizens being active in general, and citizens socializing in general within the public space, leading to the creation of liveable environment and strong communities (Koo et al., 2022; Leyden, 2003; Leyden et al., 2023). All of these are positive values for the municipality, businesses, and citizens in general.

These environmental attributes can lead to behavioural changes that could be described with the OC-matrix as a way to form, change, and reinforce behaviours and attitudes. The change depends on the citizen in question. If someone just moved to a city or is a tourist visiting a city with walkable areas from a car-oriented area, their behaviour and attitude would probably be formed, or changed. In comparison, a citizen that has always lived in a walkable city, their attitudes and behaviours would be probably unchanged or reinforced by living in such a city.

As a quite passive and mundane service, a city does not have strong signals to encourage people to perform the desired behaviours of using the space and services in it. With a walkable city, the strongest core motivators are social acceptance/rejection regarding the social aspects of being in a city, and the hope/fear and the pleasure/pain of finding new and interesting things and encounters to experience, such as buildings or landmarks, services, and people. The simplicity factors of such a city could be social deviance, non-routine, time, money, brain cycles and physical effort, as the experience of using city's services are varied and complex, because people a wide variety of different motivations to use these services. Walkable cities work as a facilitator and signal triggers to encourage people to use the city's services and as a general encouragement to inspire people to investigate and experience the city as a whole.

The city's liveability and walkability or gameful experiences in co-operation with the services is its affordance. Affordances make it possible for the city to operate as an enjoyable environment which is capable of producing gameful or game like experiences for its citizens. Without these affordances of a liveable city, it would be challenging to have gameful experiences when the citizen is enjoying their time in the city.

Also, it could be argued that without these attributes the city does not represent a good example of urban design in the first place. As an example, Alfonzo (2005) examines walkability through the lens of their framework of The Hierarchy of Walking Needs, and notes that after the first four levels of the hierarchy (feasibility, accessibility, safety, and comfort) are met, the person considers their walking experience. Alfonzo (2005) mentions diversity, complexity, liveliness, architectural coherence and scale, and aesthetic appeal, in combination with streetscapes, and activity level of the area as the enhancing element as factors that may affect the level of satisfaction and the pleasurability that the person feels, which influences the decision about the mode of transport that the person makes. This effect has been proven to take place with varying strength in many studies (e.g., Koo et al., 2022; Mehta, 2008; Shin and Woo, 2024). From the perspective of The Hierarchy of Walking Needs framework, pleasurability is the level at which gamification has the biggest potential to make an effect.

The gamefulness of cities is classified strongly with *paidia* in combination with *mimicry* and *ilinx* if the city can produce feelings of being absorbed while going through the streets, experiences for different senses such as microclimates, or interesting changes in the topography, building stock, or environment in general. Gameful dimensions that could be connected to cities vary, but the most distinct dimensions would be social experience, guided, playfulness, and immersion. Social experience is quite self-explanatory, in situations where the city has good public and private areas for social interaction, such as parks and restaurants. Guided and immersion are valid dimensions if the city succeeds in creating an environment that is interesting and enough easy to navigate, which may lead to the citizen experiencing some sort of flow state. Playfulness is another dimension that is highly linked to the urban design and how public areas are developed to produce different sorts of playfulness among different citizen demographics. Playfulness might appear as a straightforward design such as play areas for kids in the parks, or as a more vague design such as events, art, or interesting encounters that even the adult population can find fun.

Can walkable cities be gameful? As a conclusion of this evaluation, it could be stated that cities can have gameful elements in their design. These elements can be found when thoroughly examining and evaluating cities with the goal of finding gameful elements. It could be hard to specifically design these elements in a city, but many of them might be aligned with good urban design in general. Because of this it would be senseful to conclude that gameful design is probably not going to be the next big trend in urban design, but it might be one of the many points of views in holistic evaluation of the decisions we make about the development of our cities.



## 5. DISCUSSIONS AND CONCLUSIONS

In this thesis gamification was examined from the transport perspective by conducting a literature review, which was used to build a framework to ease design and evaluation processes that were assessed on five different case studies. The literature review and case studies found gameful mechanics and elements that could be connected to the field of transport with more or less direct connections. If we reflect these connections to the RQ1 “Are there linkages between gamification and modal shift towards sustainable transport modes?”, it could be concluded that there are linkages and connections. Especially findings from key areas of enhancing services, and motivation support. Enhancing services can be connected to transport as it is in its core the key area that guides the way measures can be affected by gamification. Motivation support on the other hand is about setting the goals of these measures, and the way the measures can reach the goal of modal shift. Of course, in addition to enhancing services and motivation support, gameful experiences are linked to the field of transport, especially in ways shown with case studies and the findings of chapter 3.1. Key areas value creation and affordances are connected to the field of transport more indirectly than the previously mentioned but have their relevancy in regard to detailed design processes, which consider also factors such as platforms, and end products from the lessons of affordances, and goal orientation considered with value creation.

The second research question was “What kind of framework can guide the user to design or evaluate transport related solutions that use gamification”. The framework that was created as an answer to this research question was explained in chapter 4.1. The framework was compiled from key areas found in chapter 3, and it consist of these key areas, which were arranged in a logical order that created a checklist-type structure that can be used in the design or evaluation process of different kinds of transport related solutions that use gamification. Key areas that were used in the framework are the following in the order that they appear in the framework: enhanced services, behavioural change, motivation support, affordances, and gameful experiences. The framework was tested by using it with case studies to see how it functions with different kinds of solutions, and if it is useful.

After using the framework to review five case studies it is challenging to make definitive conclusions. The positive feature of the framework is its simplicity in regards of systematically reviewing key areas of gamification in transport measures and projects, which should probably also translate from evaluation to design as it goes through steps of

things to consider in a logical order from goals to the means of measure to design. The biggest limitation of the framework is its vague nature, because it consists of simple steps that can be misinterpreted and demands a basic understanding of the key areas to use it. Also, the framework does not in its simple nature offer incentives or guidelines for a true in-depth analysis of the evaluated or designed service. After all, it can be a useful framework to guide a person that is not completely familiar with gamification to design or evaluate transport related solutions, by making sure that the process considers important key areas of gamification, and thus it gives a better chance for the solution to work, or understanding of the solution's stumbling blocks or keys to success.

The third research question was "What does the evaluated case studies tell us about the gamification in the field of transport?" First and the most self-evident fact is that gamification has already been used in transport solutions such as MUV game, CitiCAP, and the commute competitions in workplaces that have been quite common for a long time. Also, new solutions such as crowdsourcing have been utilising gamification also in the transport sector with companies like Crowdsorsa. Review of gamification in cities in general showed that we are already affected by factors that share features with gamification, and if they are recognised even better, urban design can use them more consciously in the future. Case studies also presented different ways to implement key areas of gamification in the solutions with variety in each of the key areas and approaches to them. This confirms that gamification has the potential to be used with measures that has varied approaches and styles of implementation, which opens the array of possibilities even wider.

Strength of the thesis is in its goal of being introductive and aimed at a particular group, and it is designed to serve that need. The structure is straightforward, which enables the reader to internalise a wide array of information on the topic. Also, the provided information is enough concise to be internalised easy without compromising with the amount of information considering the goals of the thesis. This enables a transport professional to get a good basic understanding of gamification, and about the ways of using gamification to enhance transport related services and promotion measures to achieve goals that they have.

The thematic literature review is probably the biggest limitation of the study, even if it is suitable for the goals of the thesis. With a systematic literature review, the amount of data could have been larger, which could have opened the possibility for more in-depth analysis and more examples of the different key areas of gamification. Another limitation was the level of examination of the case studies. Case studies were examined on a surface level to exhibit the function of the framework properly. If the goal of the thesis

had been to examine gamification on a deeper level, case studies could have been studied more thoroughly by conducting interviews with people who have been involved with the case studies, and by doing a proper in-depth analysis of the results and other documentation that has been published on the case studies.

Based on this thesis, it can be recommended to include gamification in the design processes of different kinds of transport projects. The framework can be used to help with the design process if it is needed and suitable for the project in question. Also, different key areas can be used separately to reflect with choices made within different segments of the project in question.

For future research on gamification in connection with transport, there are many possibilities. Extensive and systematic literature review of connections between transport and gamification, with a focus on the mechanism that transport and gamification share, or different kinds of transport implementations that have used gameful elements would be a natural next step. Also, case studies from these implementations could be studied more extensively by collecting positive and negative experiences about their implementations to build the best practices in a systematic way.

## REFERENCES

- Ajzen, I., 1991. The theory of planned behavior. *Organizational Behavior and Human Decision Processes* 50, 179–211. [https://doi.org/10.1016/0749-5978\(91\)90020-T](https://doi.org/10.1016/0749-5978(91)90020-T)
- Alfonzo, M.A., 2005. To Walk or Not to Walk? The Hierarchy of Walking Needs. *Environment and Behavior* 37, 808–836. <https://doi.org/10.1177/0013916504274016>
- Althoff, T., White, R.W., Horvitz, E., 2016. Influence of Pokémon Go on Physical Activity: Study and Implications. *J Med Internet Res* 18, e315. <https://doi.org/10.2196/jmir.6759>
- Azuma, R.T., 1997. A Survey of Augmented Reality. *Presence: Teleoperators & Virtual Environments* 6, 355–385. <https://doi.org/10.1162/pres.1997.6.4.355>
- Bamberg, S., Fujii, S., Friman, M., Gärling, T., 2011. Behaviour theory and soft transport policy measures. *Transport Policy* 18, 228–235. <https://doi.org/10.1016/j.tranpol.2010.08.006>
- Banister, D., 2008. The sustainable mobility paradigm. *Transport Policy* 15, 73–80. <https://doi.org/10.1016/j.tranpol.2007.10.005>
- Barratt, P., 2017. Healthy competition: A qualitative study investigating persuasive technologies and the gamification of cycling. *Health & Place* 46, 328–336. <https://doi.org/10.1016/j.healthplace.2016.09.009>
- Buckley, P., Doyle, E., 2016. Gamification and student motivation. *Interactive Learning Environments* 24, 1162–1175. <https://doi.org/10.1080/10494820.2014.964263>
- Caillois, R., Meyer, B., 2001. *Man, Play and Games*. University of Illinois Press.
- Carmigniani, J., Furht, B., Anisetti, M., Ceravolo, P., Damiani, E., Ivkovic, M., 2011. Augmented reality technologies, systems and applications. *Multimed Tools Appl* 51, 341–377. <https://doi.org/10.1007/s11042-010-0660-6>
- Caroleo, Morelli, Lissandrello, Vesco, Di Dio, Mauro, 2019. Measuring the Change Towards More Sustainable Mobility: MUV Impact Evaluation Approach. *Systems* 7, 30. <https://doi.org/10.3390/systems7020030>
- Carroll, J.M., Thomas, J.C., 1988. FUN. *ACM SIGCHI Bulletin* 19, 21–24. <https://doi.org/10.1145/49108.1045604>
- Chiesura, A., 2004. The role of urban parks for the sustainable city. *Landscape and Urban Planning* 68, 129–138. <https://doi.org/10.1016/j.landurbplan.2003.08.003>
- City of Lahti, 2021a. CitiCAP final report.
- City of Lahti, 2021b. CitiCAP key results and conclusions.
- City of Lahti, 2020. Sustainable Urban Mobility Plan.
- City of Lahti, n.d. CitiCAP-sovellus web page [WWW Document]. CitiCAP-sovellus - Lahti. URL <https://www.lahti.fi/kaupunki-ja-paatoksenteko/strategia-ja-kehittaminen/hankkeet/citicap/citicap-sovellus/> (accessed 12.30.23).
- Crowdsorsa, 2023a. Crowdsorsa home page [WWW Document]. URL <https://crowdsorsa.com/> (accessed 9.25.23).
- Crowdsorsa, 2023b. Crowdsorsa services webpage [WWW Document]. Services - Crowdsorsa. URL <https://crowdsorsa.com/services/> (accessed 2.10.23).
- Csikszentmihalyi, M., 2008. *Flow : the psychology of optimal experience*. Harper Perennial, New York.
- Csikszentmihalyi, M., 2000. *Beyond boredom and anxiety*. Jossey-bass, San Francisco.
- Currier, J., 2008. Gamification: Game Mechanics is the New Marketing [WWW Document]. URL <https://blog.oogalabs.com/2008/11/05/gamification-game-mechanics-is-the-new-marketing/> (accessed 7.28.22).
- Deterding, S., Dixon, D., Khaled, R., Nacke, L., 2011. From game design elements to gamefulness, in: *Proceedings of the 15th International Academic MindTrek Conference on Envisioning Future Media Environments - MindTrek '11*. ACM Press, New York, New York, USA, p. 9. <https://doi.org/10.1145/2181037.2181040>
- Di Dio, S., Lissandrello, E., Schillaci, D., Caroleo, B., Vesco, A., D'Heespeel, I., 2019. MUV: A Game to Encourage Sustainable Mobility Habits, in: Gentile, M., Allegra, M., Söbke, H. (Eds.), *Games and Learning Alliance, Lecture Notes in Computer Science*. Springer International Publishing, Cham, pp. 60–70. [https://doi.org/10.1007/978-3-030-11548-7\\_6](https://doi.org/10.1007/978-3-030-11548-7_6)
- Di Dio, S., Massa, F., Nucara, A., Peri, G., Rizzo, G., Schillaci, D., 2020. Pursuing softer urban mobility behaviors through game-based apps. *Heliyon* 6, e03930. <https://doi.org/10.1016/j.heliyon.2020.e03930>



- Diewald, S., Möller, A., Roalter, L., Stockinger, T., Kranz, M., 2013. Gameful design in the automotive domain, in: Proceedings of the 5th International Conference on Automotive User Interfaces and Interactive Vehicular Applications - AutomotiveUI '13. ACM Press, New York, New York, USA, pp. 262–265. <https://doi.org/10.1145/2516540.2516575>
- European Commission, n.d. Mobility Urban Values [WWW Document]. URL <https://cordis.europa.eu/project/id/723521>
- European Environment Agency, 2022. Decarbonising road transport: the role of vehicles, fuels and transport demand. Publications Office of the European Union. <https://doi.org/10.2800/68902>
- Fogg, B., 2009. A behavior model for persuasive design, in: Proceedings of the 4th International Conference on Persuasive Technology. Presented at the Persuasive 2009: Persuasive 2009; 4th International Conference on Persuasive Technology, ACM, Claremont California USA, pp. 1–7. <https://doi.org/10.1145/1541948.1541999>
- Frith, J., 2013. Turning life into a game: Foursquare, gamification, and personal mobility. *Mobile Media & Communication* 1, 248–262. <https://doi.org/10.1177/2050157912474811>
- Gehl, J., 2010. *Cities for People*. Island Press.
- Gehl, Jan., 2011. *Life between buildings : using public space*. Island Press, Washington, DC.
- Gibson, J.J., 1977. The theory of affordances. *Hilldale, USA* 1, 67–82.
- Google, 2023. *Crowdsorsa's Google play page [WWW Document]*. Crowdsorsa - Apps on Google Play. URL <https://play.google.com/store/apps/details?id=com.crowdsorsa> (accessed 12.30.23).
- Greeno, J.G., 1994. Gibson's affordances. *Psychological Review* 101, 336–342. <https://doi.org/10.1037/0033-295X.101.2.336>
- Hamari, J., Koivisto, J., 2015. Why do people use gamification services? *International Journal of Information Management* 35, 419–431. <https://doi.org/10.1016/j.ijinfomgt.2015.04.006>
- Hamari, J., Koivisto, J., Sarsa, H., 2014. Does Gamification Work? -- A Literature Review of Empirical Studies on Gamification, in: 2014 47th Hawaii International Conference on System Sciences. IEEE, pp. 3025–3034. <https://doi.org/10.1109/HICSS.2014.377>
- Hassan, L., Hamari, J., 2020. Gameful civic engagement: A review of the literature on gamification of e-participation. *Government Information Quarterly* 37. <https://doi.org/10.1016/j.giq.2020.101461>
- Hendriksen, I.J.M., Simons, M., Garre, F.G., Hildebrandt, V.H., 2010. The association between commuter cycling and sickness absence. *Preventive Medicine* 51, 132–135. <https://doi.org/10.1016/j.ypmed.2010.05.007>
- Hillnhütter, H., 2022. Stimulating urban walking environments – Can we measure the effect? *Environment and Planning B: Urban Analytics and City Science* 49, 275–289. <https://doi.org/10.1177/23998083211002839>
- Högberg, J., Hamari, J., Wästlund, E., 2019. Gameful Experience Questionnaire (GAMEFUL-QUEST): an instrument for measuring the perceived gamefulness of system use. *User Modeling and User-Adapted Interaction* 29, 619–660. <https://doi.org/10.1007/s11257-019-09223-w>
- Hollingsworth, J., Copeland, B., Johnson, J.X., 2019. Are e-scooters polluters? The environmental impacts of shared dockless electric scooters. *Environ. Res. Lett.* 14, 084031. <https://doi.org/10.1088/1748-9326/ab2da8>
- Humpel, N., 2002. Environmental factors associated with adults' participation in physical activity A review. *American Journal of Preventive Medicine* 22, 188–199. [https://doi.org/10.1016/S0749-3797\(01\)00426-3](https://doi.org/10.1016/S0749-3797(01)00426-3)
- Hunter, R.F., de Silva, D., Reynolds, V., Bird, W., Fox, K.R., 2015. International inter-school competition to encourage children to walk to school: a mixed methods feasibility study. *BMC Research Notes* 8, 19. <https://doi.org/10.1186/s13104-014-0959-x>
- Huotari, K., Hamari, J., 2012. Defining gamification: a service marketing perspective, in: Proceedings of the 16th International Academic MindTrek Conference on - MindTrek '12. ACM Press, New York, New York, USA, p. 17. <https://doi.org/10.1145/2393132.2393137>
- Jacobsen, P.L., 2003. Safety in numbers: more walkers and bicyclists, safer walking and bicycling. *Injury Prevention* 9, 205–209. <https://doi.org/10.1136/ip.9.3.205>
- Klanjčić, M., Gauvin, L., Tizzoni, M., Szell, M., 2022. Identifying urban features for vulnerable road user safety in Europe. *EPJ Data Science* 11, 27. <https://doi.org/10.1140/epjds/s13688-022-00339-5>
- Koo, B.W., Guhathakurta, S., Botchwey, N., 2022. How are Neighborhood and Street-Level Walkability Factors Associated with Walking Behaviors? A Big Data Approach Using Street

- View Images. *Environment and Behavior* 54, 211–241. <https://doi.org/10.1177/00139165211014609>
- Kuramoto, I., Ishibashi, T., Yamamoto, K., Tsujino, Y., 2013. Stand Up, Heroes! : Gamification for Standing People on Crowded Public Transportation. pp. 538–547. [https://doi.org/10.1007/978-3-642-39241-2\\_59](https://doi.org/10.1007/978-3-642-39241-2_59)
- Leyden, K.M., 2003. Social Capital and the Built Environment: The Importance of Walkable Neighborhoods. *Am J Public Health* 93, 1546–1551. <https://doi.org/10.2105/AJPH.93.9.1546>
- Leyden, K.M., Hogan, M.J., D'Arcy, L., Bunting, B., Bierema, S., 2023. Walkable Neighborhoods: Linkages Between Place, Health, and Happiness in Younger and Older Adults. *Journal of the American Planning Association* 1–14. <https://doi.org/10.1080/01944363.2022.2123382>
- Li, Y., 2003. Evaluating the Urban Commute Experience: A Time Perception Approach. *Journal of Public Transportation* 6, 41–67. <https://doi.org/10.5038/2375-0901.6.4.3>
- Litman, T., Burwell, D., 2006. Issues in sustainable transportation. *International Journal of Global Environmental Issue* 6, 331–347.
- Loukopoulos, P., 2007. A classification of travel demand management measures, in: *Threats from Car Traffic to the Quality of Urban Life*. Emerald Group Publishing Limited, pp. 273–292.
- Lynch, Kevin., 1960. *The image of the city*. M.I.T. Press, Cambridge (Mass.).
- Malone, T., 1981. Toward a theory of intrinsically motivating instruction. *Cognitive Science* 5, 333–369. [https://doi.org/10.1016/S0364-0213\(81\)80017-1](https://doi.org/10.1016/S0364-0213(81)80017-1)
- McDaniel, R., Lindgren, R., Friskics, J., 2012. Using badges for shaping interactions in online learning environments, in: *2012 IEEE International Professional Communication Conference*. IEEE, pp. 1–4. <https://doi.org/10.1109/IPCC.2012.6408619>
- Mehta, V., 2008. Walkable streets: pedestrian behavior, perceptions and attitudes. *Journal of Urbanism: International Research on Placemaking and Urban Sustainability* 1, 217–245. <https://doi.org/10.1080/17549170802529480>
- Meschtscherjakov, A., Trösterer, S., Lupp, A., Tscheligi, M., 2017. Pokémon WALK: Persuasive Effects of Pokémon GO Game-Design Elements. pp. 241–252. [https://doi.org/10.1007/978-3-319-55134-0\\_19](https://doi.org/10.1007/978-3-319-55134-0_19)
- Millonig, A., Wunsch, M., Stibe, A., Seer, S., Dai, C., Schechtner, K., Chin, R.C.C., 2016. Gamification and Social Dynamics Behind Corporate Cycling Campaigns. *Transportation Research Procedia* 19, 33–39. <https://doi.org/10.1016/j.trpro.2016.12.065>
- Morschheuser, B., Hamari, J., Maedche, A., 2019. Cooperation or competition – When do people contribute more? A field experiment on gamification of crowdsourcing. *International Journal of Human-Computer Studies* 127, 7–24. <https://doi.org/10.1016/j.ijhcs.2018.10.001>
- Musselwhite, C., Haddad, H., 2010. Mobility, accessibility and quality of later life. *Quality in Ageing and Older Adults* 11, 25–37. <https://doi.org/10.5042/qiaoa.2010.0153>
- MUV B Corp, 2023. MUV game web page [WWW Document]. MUV Game - App that seeks to encourage safe and sustainable mobility. URL <https://www.muvgame.com/en/> (accessed 1.7.23).
- O'Hern, S., Oxley, J., 2015. Understanding travel patterns to support safe active transport for older adults. *Journal of Transport & Health* 2, 79–85. <https://doi.org/10.1016/j.jth.2014.09.016>
- Oinas-Kukkonen, H., 2013. A foundation for the study of behavior change support systems. *Personal and Ubiquitous Computing* 17, 1223–1235. <https://doi.org/10.1007/s00779-012-0591-5>
- Oja, P., Vuori, I., Paronen, O., 1998. Daily walking and cycling to work: their utility as health-enhancing physical activity. *Patient Education and Counseling* 33, S87–S94. [https://doi.org/10.1016/S0738-3991\(98\)00013-5](https://doi.org/10.1016/S0738-3991(98)00013-5)
- Paavilainen, J., Korhonen, H., Alha, K., Stenros, J., Koskinen, E., Mayra, F., 2017. The Pokémon GO Experience: A Location-Based Augmented Reality Mobile Game Goes Mainstream, in: *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*. Presented at the CHI '17: CHI Conference on Human Factors in Computing Systems, ACM, Denver Colorado USA, pp. 2493–2498. <https://doi.org/10.1145/3025453.3025871>
- Pelling, N., 2002. Conundra Ltd Home Page [WWW Document]. URL <http://www.nanodome.com/conundra.co.uk/> (accessed 7.28.22).
- Rabl, A., de Nazelle, A., 2012. Benefits of shift from car to active transport. *Transport Policy* 19, 121–131. <https://doi.org/10.1016/j.tranpol.2011.09.008>
- Reeves, B., Read, J.L., 2009. *Total engagement: using games and virtual worlds to change the way people work and businesses compete*. Mass: Harvard Business Press, Boston.

- Rutter, H., Cavill, N., Racioppi, F., Dinsdale, H., Oja, P., Kahlmeier, S., 2013. Economic Impact of Reduced Mortality Due to Increased Cycling. *American Journal of Preventive Medicine* 44, 89–92. <https://doi.org/10.1016/j.amepre.2012.09.053>
- Sælensminde, K., 2004. Cost–benefit analyses of walking and cycling track networks taking into account insecurity, health effects and external costs of motorized traffic. *Transportation Research Part A: Policy and Practice* 38, 593–606. <https://doi.org/10.1016/j.tra.2004.04.003>
- Saunders, M., Lewis, P., Thornhill, A., 2019. *Research Methods for Business Students*.
- Seaborn, K., Fels, D.I., 2015. Gamification in theory and action: A survey. *International Journal of Human-Computer Studies* 74, 14–31. <https://doi.org/10.1016/j.ijhcs.2014.09.006>
- Shin, H.-S., Woo, A., 2024. Analyzing the effects of walkable environments on nearby commercial property values based on deep learning approaches. *Cities* 144, 104628. <https://doi.org/10.1016/j.cities.2023.104628>
- Smith-McLallen, A., Heller, D., Vernisi, K., Gulick, D., Cruz, S., Snyder, R.L., 2017. Comparative Effectiveness of Two Walking Interventions on Participation, Step Counts, and Health. *American Journal of Health Promotion* 31, 119–127. <https://doi.org/10.1177/0890117116658012>
- Stevens, Q., 2007. *The Ludic city : exploring the potential of public spaces*. Routledge, New York.
- Stewart, W.F., 2003. Lost Productive Time and Cost Due to Common Pain Conditions in the US Workforce. *JAMA* 290, 2443. <https://doi.org/10.1001/jama.290.18.2443>
- Stinson, J.N., Jibb, L.A., Nguyen, C., Nathan, P.C., Maloney, A.M., Dupuis, L.L., Gerstle, J.T., Alman, B., Hopyan, S., Strahlendorf, C., Portwine, C., Johnston, D.L., Orr, M., 2013. Development and Testing of a Multidimensional iPhone Pain Assessment Application for Adolescents with Cancer. *J Med Internet Res* 15, e51. <https://doi.org/10.2196/jmir.2350>
- Te Brömmelstroet, M., Nikolaeva, A., Mladenović, M., Milakis, D., Ferreira, A., Verlinghieri, E., Cadima, C., de Abreu e Silva, J., Papa, E., 2022. Have a good trip! expanding our concepts of the quality of everyday travelling with flow theory. *Applied Mobilities* 7, 352–373. <https://doi.org/10.1080/23800127.2021.1912947>
- The City of Helsinki's Urban Environment, 2022. Vihreät sylit - on Helsingin kaupungin puistosivusto, joka vie kävelyretkille pääkaupungin ihastuttaviin ja monimuotoisiin puistoihin. Ota puistot omaksesi! [WWW Document]. URL <https://vihreatsylit.fi> (accessed 1.31.23).
- Uttley, J., Lovelace, R., 2016. Cycling promotion schemes and long-term behavioural change: A case study from the University of Sheffield. *Case Studies on Transport Policy* 4, 133–142. <https://doi.org/10.1016/j.cstp.2016.01.001>
- van der Heijden, 2004. User Acceptance of Hedonic Information Systems. *MIS Quarterly* 28, 695. <https://doi.org/10.2307/25148660>
- Visser, M., Pluijm, S.M.F., Stel, V.S., Bosscher, R.J., Deeg, D.J.H., 2002. Physical Activity as a Determinant of Change in Mobility Performance: The Longitudinal Aging Study Amsterdam. *Journal of the American Geriatrics Society* 50, 1774–1781. <https://doi.org/10.1046/j.1532-5415.2002.50504.x>
- Wallius, E., Thibault, M., Apperley, T., Hamari, J., 2022. Gamifying the city: E-scooters and the critical tensions of playful urban mobility. *Mobilities* 17, 85–101. <https://doi.org/10.1080/17450101.2021.1985382>
- Wentzel, K.R., 1994. Relations of social goal pursuit to social acceptance, classroom behavior, and perceived social support. *Journal of Educational Psychology* 86, 173–182. <https://doi.org/10.1037/0022-0663.86.2.173>
- Wind, 2023. Wind homepage [WWW Document]. URL <https://wind.yango.com/> (accessed 1.19.23).
- World Commission on Economic Development, 1987. *Our Common Future*. Report of the World Commission on Environment and Development. Oxford University Press, Oxford.
- World Health Organization, 2017. *Health economic assessment tool (HEAT) for walking and for cycling: Methods and user guide on physical activity, air pollution, injuries and carbon impact assessments*. World Health Organization.