Anastasia Maydanova

ENGAGING CITIZENS OF TAMPERE THROUGH SUSTAINABLE SMART CITY TECHNOLOGIES: AR APPLICATION DESIGN PROPOSAL

ABSTRACT

Anastasia Maydanova: Engaging Citizens of Tampere through Sustainable Smart City
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Creating resilient and inclusive cities is one of the widely recognized priorities in sustainable development. Making cities smart is essential to achieving this goal, and it would not be feasible without certain elements that urban planning should incorporate. The thesis aims to enhance understanding of Smart City Technologies (SCTs) and their role in sustainable development among Tampere's residents, using a mobile app with augmented reality (AR) features.

The thesis centers around three primary ideas: (1) the integration of Smart City Technologies (SCTs) in urban planning, (2) the utilization of gamification technologies for motivation, and (3) exploring the connection between the environment and citizens through Playfulness and Augmented Reality (AR). This research employs both quantitative and qualitative methods to conduct a comprehensive analysis of existing data, extracting valuable insights from the target audience. Additionally, to provide a broader perspective on the proposed topic and highlight successful instances of smart cities, the thesis incorporates relevant case studies and analysis of previous studies.

The research indicates a strong desire among individuals to create communities and collaboratively contribute to sustainable development and that designing a mobile application with AR features can introduce an element of playfulness to the urban environment. This approach could encourage citizens to partake in enjoyable activities, such as completing tasks and prompting them to explore their surroundings critically, providing insights for potential modifications. Additionally, study participants emphasize the importance of integrating cultural heritage and social aspects into urban development to achieve sustainability. Consequently, the application has the potential to yield positive outcomes for the city's urban development, serving as a subtle educational tool for both local and international residents about sustainable development.

Key words and terms: Smart City, Sustainability, Augmented Reality, Participatory Design Research

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

LIST OF ABBREVIATIONS

AR   Augmented Reality

DIY   Do-It-Yourself

HCI   Human-Computer Interaction

HTI   Human-Technology Interaction

ICTs   Information and Communication Technologies

IoT   Internet of Things

SCTs   Smart City Technologies

UI   User Interface

UX   User Experience

VR   Virtual Reality

CONTENTS

1   INTRODUCTION

This thesis investigates how novel technologies could be used for urban development and the improvement of citizens' perception of serious topics (e.g. Smart City concept and sustainability). The study consists of several research stages: conceptualisation, initial research, participatory design research and creation of a low-fidelity mobile application prototype.

1.1 Research problem

Sustainable development encompasses 17 key Goals (SDGs) developed by the United Nations that serve as a framework for governments, policy- and decision-makers to meet the requirements of SDGs and transform accustomed processes, making them resilient to sustainability challenges. One of the SDGs is Goal 11 which is aimed at building sustainable and inclusive cities and communities. The Goal includes, among others, enhancing technologies within the cities, increasing safety, reasonably distributing and managing the resources, and providing accessible public spaces (*Goal 11 | Department of Economic and Social Affairs*, n.d.). To meet this Goal, it is crucial to make cities smart, and it would be possible without specific aspects that should be implemented in urban development.

Tampere is a Smart City which is constantly being developed to improve its operations. The municipality of this city supervises development projects, so they align with the SDGs. Thus, their results would positively affect not only life within Tampere but also contribute to the general improvement of functioning processes, services and operations relating to a thriving and sustainable city. Along with solutions that would encourage citizens to participate in social activities and discover the cultural heritage, the City of Tampere implements Smart City Technologies with the assistance of relevant companies to ensure faster achievement of Goal 11 of SDGs. One of them is Sitowise Oy.

Sitowise Oy is a company that specialises in the implications of Smart City Technologies in urban development and introducing efficient solutions to improve the process flow within the city. The main activity of the organisation is divided into 3 main spheres: digital smart solutions, sustainable infrastructure design and building design (Sitowise Q&A, 2020). The approach of the

company is based on the efficient use of resources as well as communicating with end users to underline their needs for future city development. Sitowise equates the 'smartness' and sustainability of the city to highlight that a smart city is not only aimed at technology implementation to make the environment more digitalised, but to use these technologies to allow citizens to make sustainable choices effortlessly (Sitowise Q&A, 2020). Sitowise offers its services across Finland, and they have a diverse portfolio of successful cases of city infrastructure improvement.

To achieve a faster and smoother achievement of Goal 11, the company started to consider which actions could be taken to encourage citizens of Tampere to know more about technologies that assist with the transition to sustainable operations. However, Sitowise is not aware of the initial assumptions of Tampere's residents regarding SCTs and sustainability. Henceforth, it highlighted the urgent need to promote sustainable Smart City Technologies to Tampere's citizens (both local and international). Sitowise's interest in the research became a starting point of the following study.

Nowadays, to promote serious topics to a wide audience it is crucial to make information accessible and inclusive, and to use novel channels of information distribution. Educational platforms are rather widespread globally, but deploying SCTs directly to the user on the move through mobile broadband connections to important data would increase the chance of their participation in the learning process. To motivate users even more, the implementation of playful interactions might bring beneficial results.

Since the concept of the Smart City may be considered technocratic, the creative approach to its promotion should be considered since cities are the reflection of socioeconomic levels of citizens' lives and their culture (Thibault & Bujić, 2020). With the current discussion regarding virtual realities, the augmentation of physical world with digital artefacts could create the desirable interest from individuals to the Smart City concept and sustainability. Playful interventions within the city with the use of Augmented Reality features might enhance people's feeling of presence and mitigate the existing gaps between urban development and citizens' needs and provide possible ideas for city's development in future (Thibault & Bujić, 2020). In addition, AR technologies could demonstrate opportunities to develop accessible and inclusive virtual interactivities options for local and international residents.

1.2 Research Objectives

The goal of this study is to examine how to improve the understanding of Smart City Technologies (SCTs) and their contribution to sustainable development among the residents of Tampere (both local and international) with the use of mobile application with AR features.

To this end, the effect of combination of playfulness and AR technologies with a serious topic is explored through a qualitative study and followed by a design of a low-fidelity mobile application prototype. The qualitative study is expected to aid in outlining necessary features that enhance citizens' perception of their environment and motivation to act and collaborate.

Therefore, in this research, the collection of qualitative data is prioritised to achieve the required results. The related literature and previous findings are essential to form a substantial study foundation to assist with conceptualisation and framework development.

1.3 Thesis Outline

The thesis is structured as follows. In Chapter 1, the research problem and research objectives are given. Chapter 2 is dedicated to the analysis of related works, and it discusses several concepts: 1) Smart City, 2) gamification technologies, 3) Augmented Reality, 4) playable cities, and 5) DIY urban movement. In this Chapter, the relationship between these concepts is studied, and the review is followed by the framework of the study and research questions.

Chapter 3 underlines the paradigms that were chosen for the study. Then, the methodological approach is provided. In this Chapter, the results of collaborative interviews with HCI students and the interview with the Sustainability Consultant from Sitowise are presented to highlight important aspects that support the following research methods.

Chapter 4 is devoted to the process of workshop development. It subsequently describes the activities that were offered during the workshop and states the crucial findings for the next stage of research.

Chapter 5 illustrates the low-fidelity prototype design that was created based on the findings from preceding research methods. The Chapter is finalised by the evaluation of the prototype. There is given a detailed analysis of shares of respondents' answers related to the low-fidelity mobile application prototype' design and features, and the share of responses among attendees. Then, the average rating for the application is provided with the formula that was used to extract the result.

Findings are demonstrated in Chapter 6. There is given a reflection on the results of the application design analysis, and crucial aspects for decision-makers and developers are outlined. Additionally, the research question and sub-question are reviewed. The Chapter concludes with a discussion of aspects that could be studied by academics.

Chapter 7 highlights the importance of ethical approach in academic research. In this Chapter, trustworthiness, credibility and ethical aspects of the study are considered.

In Chapter 8, the summary of the thesis is provided. In addition to that, the implication of the study is given, and limitations and possibilities for future work are listed.

2   CONCEPTUALISATION

As a starting point, it is crucial to analyse previous research related to the topic to evaluate the direction of further research steps. In addition to that, the literature review will assist in highlighting not only similar patterns but also missing aspects or the 'blind spots' recognized in the literature.

The final steps of the research will be devoted to the exploration of how citizens of Tampere (both local and international) perceive the concept of Smart City Technologies and their contribution to sustainable development, and how individuals can be subtly educated on the topic through playful gamified activities.

Henceforth, to recognize the scope of discussed research questions by other scholars, the necessity to underline the main concept of this study was evident. The chosen concepts are listed below:

- The Smart City concept;
- Smart City Technologies (SCTs) and their contribution to sustainable development;
- Playable cities and the DIY urban movement;
- Gamification technologies;
- Augmented Reality (AR).

Subsequent to this background section, the findings will be summarised to pinpoint the research question for this study.

2.1 The Smart City concept

The concept of a Smart City is mostly understood as abstract technological advancements of the city, and it may be associated with rather futuristic utopian or dystopian environments (Leorke, 2019). However, the reasons why these technologies are imperative for the process organisation within the city and how they impact sustainable development are the questions that might not have unambiguous answers from decision-makers and, most importantly, citizens.

Nowadays, a huge number of definitions of the **Smart City concept** exist in the academic field. For instance, De Bem Machado et al. (2021), delineate the term as a concept that is aimed to improve citizens' quality of life through the use of ICT technologies to create solutions to urban challenges.

In addition, Nijholt (2019) mentioned that Smart Cities make citizens' lives safer, more efficient, more sustainable, and more attractive to live in. At the same time, Leorke (2020) underlines that they provide an opportunity for creativity and cultural inclusion by collecting and analysing data of inhabitants to be leveraged to improve urban living.

Nevertheless, this concept also faces criticism from scholars. As was mentioned before, there is no universally accepted delineation of the term. Since it is now one of the most infamous paradigms of urban development, the issue that representatives of higher instances (e.g. governments) might comprehend the concept of a Smart City differently might lead to undesirable consequences (Leorke, 2019). For example, the focus of urban development might be aimed at only one facet of sustainability, excluding enhancing social well-being or preserving the natural environment. Furthermore, the technocratic approach, lack of transparency and exclusion of citizens' opinions in the decision-making process are other issues listed by researchers and academics (Leorke, 2019).

At the same time, it is worth mentioning that Smart Cities development, when approached from different angles of sustainability, might substantially change citizens' lifestyles and determine the evolution of societies and the world's processes in a long-term perspective (De Bem Machado et al., 2021). Therefore, governments and decision-makers need to provide accessible information to residents about urban development plans and what effects they will have on people's lives and the environment. By maintaining open communication with all the stakeholders, it could be doable to analyse existing issues from various perspectives and find solutions that may satisfy most of the people involved in the discussion.

According to the State of Sustainable Development report (2020) and the Sitra report (2020) with the data retrieved from respondents in Finland, people have become more concerned about climate change issues, especially the young generation. Sustainability initiatives are becoming more supported by the public, and transparency of organisations' processes is drawing the interest of people younger than 40 years old (Greene et al, 2020). At the same time, the level of general knowledge of sustainable development aspects and overall motivation is average, and Smart City Technologies are less widespread sustainable solutions that are known among the average public (Kestävä Kehitys, 2020). Both reports identified challenges related to the citizens' mindset change to accelerate the adoption of sustainable lifestyles. This underlines the necessity for Smart City Technologies promotion among the inhabitants of cities, and the need to raise their awareness and motivation to improve surrounding processes.

2.2 Smart City Technologies' contribution to sustainable development

At first, the concept of Smart Cities was distinguished as the technological development of cities to solve urban issues with the help of the Internet of Things (IoT) and other Information and Communication Technologies (ICTs) to digitally improve the processes within the city (Okello & Akoko, 2023). In recent studies, Ahvenniemi et al. (2017) pointed out that people perceive the concept as a combination of responsible energy and resource use, technology implementation and transportation system advancements. At the same time, scholars observed that the environmental contribution of Smart Cities is underrepresented in a general discussion. Therefore, the need to underline the red thread that connects the smartness of the city and its contribution to sustainable development is being discussed among academics and decision-makers, as it would assist with improving the general public's knowledge on the topic.

It is crucial to understand that sustainability does not only embrace environmental support and conservation. This term encompasses 3 pillars: economic, societal and environmental (Purvis et al., 2019). Thus, it is important to comprehend that sustainable development involves such aspects as providing accessible spaces, reducing inequality, enhancing services within the living spaces, employment opportunities, and others. Each of these pillars should be equally acknowledged by the higher instances to achieve a balanced development (Purvis et al., 2019). Otherwise, while focusing only on one facet of sustainability, one may risk damaging the process flow in other fields. This highlights the necessity to analyse the principles of sustainable development of every facet when it comes to urban development and the implementation of SCTs, as they should improve the quality of citizens' lives without damaging the current environmental state and bring long-term economic profit.

Smart City Technologies are essential components that assist in the enhancement of services and processes within the city's environment, analysing and distributing data among interconnected platforms and stakeholders (Gade, 2023). Smart Cities depend on access to actual information, and rapid and seamless exchange of necessary data may significantly improve the run and quality of a city's operations. According to Gade (2023), the following SCTs are crucial in a Smart City development process:

- Blockchain;
- Big Data & Data Analytics;
- Cloud Computing;
- Internet of Things;
- Machine Learning;
- Digital Twin;

- Artificial Intelligence;
- 5G communication;
- Augmented Reality & Virtual Reality;
- Video Analytics.

By integrating them into the urbanisation process, it is possible to solve real-life challenges by applying innovative solutions that would improve citizens' well-being and the general liveability and likeability of a city (Gade, 2023). For instance, these technologies can contribute to the development of smart services within a city, such as smart transportation and mobility, smart waste and water management, smart governance and education. These digital solutions directly affect citizens' lives since they not only reduce the costs of living but also provide personal data protection, accessible services, equal and wise use and distribution of resources, transparency and minimising environmental deterioration as well (Gade, 2023).

Nowadays, in addition to the implementation of smart technologies, the environmental and social aspects of the city's environment are being discussed by experts. The 'smartness' of a city is perceived through cultural adaptations, citizens' lifestyle analysis, and the emotional value the city proposes to its inhabitants (Nihjolt, 2019). Toli and Murtagh (2020) highlighted that sustainable Smart Cities are mindful of environmental impact reduction as well as connecting citizens with nature and enhancing their relationships with it. In addition, the authors determine that Smart Cities from a sustainability perspective focus on citizens' well-being and promotion of communities' autonomy, protection of natural habitats and fulfilment of humans' needs. Toli and Murtagh (2020) also specified that sustainable Smart Cities holistically approach the development processes with regard to all of the sustainability facets. Silva et al. (2018) argue that Smart Cities' composition enhances the quality of citizens' lives by not only providing accessible and efficient services but also by increasing citizens' awareness and level of responsibility. Therefore, despite the possible technocratic view on the concept, the implementation of Smart City Technologies affects different sustainability facets and assists with the creation of resilient, likeable and liveable urban spaces.

Nevertheless, the education of inhabitants is a crucial part of Smart City development to mitigate sustainability issues and subtly change citizens' perceptions of the surrounding processes, leading to a possible swift of people's behavioural and consumption patterns. As Şanta (2022) argues, understanding the topic and feeling of connection and responsibility may transform the paradigm of consumers to prosumers, i.e., the willingness of people to not only use the resources but contribute to their creation.

The Table below demonstrates the key recognisable aspects of Smart and Sustainable Cities. However, one does not exclude the other, thus, the smartness of a city can directly affect its sustainable development.

TABLE 1. Features of Smart and Sustainable Cities

Smart City	Sustainable City
Intelligent Transportation and Mobility Systems	Intelligent Lighting System
IoT and Intelligent Shopping	Community Engagement and Citizens' Participation
Data Privacy and Cybersecurity	Accessible Services
Water and Waste Management	Employment Opportunities
Digital Connectivity and Broadband Access	Indigenous Societies and Practices Protection
Smart Buildings and Infrastructure	Green Spaces
Smart Use of Energy and Resources	Cultural Heritage
Intelligent Manufacturing, Farming and Agriculture	
Healthcare Accessibility	

2.3 Playable cities and DIY urban movement

To engage citizens in the process of urban development, it is possible to implement playful aspects that could creatively approach current matters in question and provide a broader perspective on the topic, possibly leading to economic improvements in the city's operations (Leorke, 2019). Smart Cities, as a concept, may sound rather distant to the average public, therefore, residents' inclusion in the discussion through generally appreciated game-like activities can beneficially affect future urban development.

Leorke (2019) argues that the implementation of playful interactions in the city environment may subtly erase the technological-only association with the Smart City concept, bringing humanity and social aspects to it. A **playable Smart City** indicates that in addition to the 'classic' smart city concept, there are also game-like elements implemented to address a specific issue or process within

the city. Nijholt (2019) assumes that smart cities can be sustainable as well as fun and entertaining. Playful technologies within the city might create an emotional connection between inhabitants and their surroundings and improve people's approach to ordinary activities such as crossing the road or waiting for a bus. This playable aspect can address the citizens' emotional state and behaviour and contribute to positive changes in the city's landscape and internal processes (Nijholt, 2019).

Muehlhaus et al. (2023) claimed that public participation in urban planning can also be improved by increasing the citizens' level of engagement with gamification. Playful gamified elements in that case will provide accessible information coherently, so individuals will not be overwhelmed by unknown terms and complicated explanations. The authors outlined that the scrupulous design of gamification aspects, including narratives, achievement systems, and quests significantly improves individuals' participation in activities within the city. In addition, this could be beneficial in several ways: 1) people will be involved in the co-creation of public environments, 2) they will get the chance to provide feedback in an easy manner, 3) they can educate themselves and have access to the information related to city's development (Muehlhaus et al., 2023).

Leorke (2020) claims that playful elements can bring modification to the smart infrastructure of the city and reappropriate public spaces to oppose the techno-centric image that smart cities have. By providing entertaining aspects, the citizens' perception of smart cities might be gradually changed, and individuals can be stimulated to interact with the environment even without any productive outcome only to gain a positive experience (Leorke, 2020).

Considering an emerging **DIY (Do-It-Yourself) movement** within the city spaces, Donovan (2014) highlights that these playful and sudden interventions might envision possible solutions to current issues from citizens' perspectives. DIY approach augments and enhances existing infrastructure from citizens' point of view, making the results functional and seamlessly integrated into the urban design (Finn, 2014). With these creative involvements from the citizens' side, people can contribute to urban development and showcase possible issues that currently exist at certain locations (Hassan & Thibault, 2019). DIY in urban planning involves a high participation and emotional attachment level even without using high-cost resources. This movement is usually created from small groups to ordinary citizens; however, the results can be analysed by the authorities to propose an effective urban solution later. Such DIY urban movement allows individuals to rethink the purpose of a city's environment and make it more likeable to inhabitants. Hassan & Thibault (2019) outlined a variety of techniques for this activity:

- *chair bombing*: the creation of seating places due to their lack;

- *DIY wayfinding*: self-made signs that would help one to navigate his or her way within the city;

- *paint bombing*: the creation of painted unauthorised bike lanes;

- *guerilla gardening*: planting vegetation in city spaces;

- *seed bombing*: leaving small vessels full of seeds in different city locations for them to bloom.

DIY approaches allow one to creatively rethink the problems related to urban planning (Donovan, 2014); therefore, this might be a reasonable option for governments to engage and communicate with citizens and exchange feedback. Nevertheless, such an approach might be condemned as most of the abovementioned activities are not authorised with the higher instances. Thus, the DIY urban movement could unintentionally be included in the same area as vandalism or used in the critical rhetoric of conservative decision-makers.

Nevertheless, encouraging citizens to participate in urban development can be considered as a significant step towards the creation of sustainable city. Paraschivoiu et al. (2022) argue that participatory urban planning provides accessibility and fosters inhabitants' well-being since their opinions are included in the discussion. Thus, it may encompass support and the necessary transparency in the process of urban development. Additionally, Christodoulou et al. (2018) claim that it is imperative to allow the public to be involved in the urbanisation of their cities as it is an inextricable part of a democratic society. From the decision-makers' side, it is crucial to educate residents of the city on the resources and the city's opportunities to create meaningful urban enhancements (Christodoulou et al., 2018). Therefore, it is necessary to find a balance between citizens' interventions into the city environment and negative aspects that they may bring such as safety and accessibility issues, budget costs and long-term effects on urban development (Finn, 2014).

2.4 Gamification technologies

Gamification, as a term, has significantly evolved throughout time. Nowadays, apart from overviewing it as an implementation of game elements to non-game contexts and making serious topics accessible to people from different backgrounds, the motivational aspects are being covered as well (Zvereva et al., 2023). Gamification aspects are used in diverse fields, and the way they affect users' intrinsic and extrinsic motivation is studied by many experts. The game-like elements that are implemented in a conventional environment considerably change the approach that individuals have when interacting with them (Alsawaier, 2018). Thus, gamification technologies that are appropriate

for a certain theme could beneficially impact the motivation of individuals as well as the process of their education. At the same time, it is important to maintain a balance between the task the user must do, and the feeling of fun he or she gets, to sustain the heuristic without discouraging users from continuing the pursuits. When applied to the education process, gamification is considered as a set of techniques and tools that would enhance the learning process by providing positive experiences and possibly affecting the behavioural patterns of those who are directly involved in the activity (Zvereva et al., 2023).

Khuzzan et al. (2021) mentions several **gamification technologies** that are widely used in education. Based on the goals of the process, the motivations of participants and their player types, these technologies could be incorporated both individually or in combination (Khuzzan et al., 2021). For instance, the most acknowledged technologies are connected to competition and obtaining achievements. These include points collection, badges, levels and leaderboards. Furthermore, Khuzzan et al. (2021) mention avatars, challenges and rewards as factors that might affect the motivations of players as they encourage them to continue the activity by providing additional value to it (e.g. avatar modifications or unique prizes). However, as technological progress has moved forward, the complexity and innovativeness of gamification technologies have evolved accordingly.

What is important to note is that gamification offers a number of benefits for increasing public involvement and educating about serious topics, (e.g. environmental awareness). Apart from its playful core, gamification can enhance an individual's aptitude for problem-solving and empathy. Additionally, it could resonate with people's desire for entertainment and positive emotions, and can also ignite one's intrinsic motivation, leading to the commitment of long-term objectives and, ultimately, playful reinforcement of engagement (Hamari, 2019). These aspects are significant for practices that require continuous commitment.

Nowadays, gamification increasingly leverages emerging mediums such as Augmented Reality (AR). This realm provides an immersive experience for users and allows them to participate in the activities offered with less distraction from external stimuli (Guillen et al., 2021). With the use of AR technology developers can mix real environment and digital world they created and provide additional experiences for users. Therefore, this might be a suitable solution to address serious topics of SCTs and their contribution to sustainable development and make the process engaging, playful and memorable.

2.5 Augmented Reality (AR) effect on people's engagement

With the widespread use of novel technologies that could provide additional experiences, the most infamous ones have become Virtual Reality (VR) and Augmented Reality (AR). However, while sharing some similar features, they drastically differ in their application and contexts they could be implemented. Both technologies could have a compelling potential to revolutionise traditional approaches in spheres such as education as they create dynamic opportunities for interaction and communication (Al-Ansi et al., 2023). Nevertheless, when analysing both technologies, it is crucial to distinguish key differences between them and investigate their limitations and opportunities.

Since VR technologies require full immersion in the virtual environment and a higher level of interaction responses, **AR technologies** encompass both real and digital realms, depending on the contextuality (Al-Ansi et al., 2023). Additionally, another crucial difference between AR and VR technologies is accessibility and costs. As Al-Ansi et al. (2023) argue, the price of these innovative solutions might be unaffordable, smartphone-based AR can be considered as a more reasonable option since it does not require additional headsets to be engaged in the activity. One of the most common uses of AR is the use of a mobile application and its integrated camera to be able to augment reality. Thus, it could be easier for individuals to use AR in their everyday lives as almost all of the world's population has powerful mobile devices with cameras. VR, on the other hand, possesses greater immersion effects. Yet, when it comes to safety, AR could be considered as a more appropriate solution rather than VR. Thus, individuals will not risk being involved in a suggested activity since they will possess more autonomy and will be more present in the real environment to evaluate their surroundings.

When it comes to motivational factors, Al-Ansi et al. (2023) highlight that the use of AR in somewhat dull or serious contexts positively affects the performance of users and their level of comprehension of a certain topic. Authors mention that AR could be implemented as in educational institutions (e.g. schools and universities), as in theatres, museums, and exhibitions. With this technology, it is possible to approach physical objects in an innovative way, and visual virtual aspects could assist with the understanding of specific aspects, making the learning process more accessible, engaging and fun (Al-Ansi et al., 2023).

Moving to the urban environment contexts, technologies that can augment reality by implicating virtual attributes might bring novelty and lucidity to citizens' experiences within the city, as well as interactively convey new data to individuals and improve their cognitive performance (Laukkanen et al., 2022). Moreover, when it comes to the convergence of AR technologies, individuals' lifestyles and sustainability, Laukkanen et al. (2022) argue that virtual technologies can

demonstrate to end users the environmental impact their actions have, subsequently raising awareness regarding this issue and mitigating people' carbon footprint in future. Subtle nudging to make greener choices may come from nature sounds implementation and amplification of wildlife presence.

Moreover, citizens can experience different situations in safe surroundings, so this multidimensional occurrence might affect individuals' choice-making (Laukkanen et al., 2022). Christodoulou et al. (2018) assume that through the use of AR or VR technology, it is possible to increase the participation level in urban planning development even for those who do not have an architectural background. The authors claim that immersive technologies allow inhabitants to gain access to data and mitigate the knowledge gap related to the processes within the city, and subsequently, this will increase the level of interest to meaningfully participate in urban development. Additionally, these technologies help the authorities communicate with citizens and obtain their feedback and proposals for specific issues within the city in a playful and engaging way (Christodoulou et al., 2018). This will promote social inclusion and improve the quality of life in cities.

As far as the research shows, AR is mostly used for entertainment purposes when it comes to mobile application development. One of the well-known examples of such AR technologies that could be applied to the urban environment is Pokémon GO. While exploring the real environment, players engage in virtual activities (e.g. catching Pokémons and fighting monsters). Figure 1 demonstrates the interface of this application.

FIGURE 1. Pokémon GO gameplay and the use of integrated camera. Source: Inc.com

This combination of fantasy and reality demonstrated a high level of involvement of players in the game process which positively affected their vital characteristics by enhancing their physical activity level (Jumareng et al., 2022). Jumareng et al. (2022) mentioned that with the assistance of an AR application, it is feasible to modify lifestyle habits and encourage individuals to move from one location to another, as Pokémon GO requires, motivating them by completing fun tasks and finding rare virtual creatures.

The research on each of the concepts has demonstrated that these topics could be studied cumulatively as they may share connected touchpoints. The work undertaken in this thesis tackles the challenges of citizen engagement in the AR setting by exploring users' needs and expectations, proposing mobile AR application design. That includes educational and playful activities on the topic of smart city technologies' contribution to sustainable development.

2.6 Design proposal

As the growth of interest towards sustainability among individuals may inextricably affect the future urban development and decision-making processes, it is imperative to foster overall knowledge of the surrounding processes within the city among Tampere's inhabitants. However, serious topics might be challenging to learn, thus, to make the information accessible, the possible solution would be to provide educational information in a playful manner and in 'bite-sized' pieces. Therefore, this work aims to highlight ways in which Tampere's citizens' awareness of the impact their decisions have on the environment, and hence may positively influence the behavioural patterns through which citizens engage the city they live in.

2.7 Framework of the Study and Research Questions

The thesis will depend on the literature review since it will provide an in-depth analysis of the previous studies and refer to the HTI.310 course findings with students from the Human-Computer Interaction master's programme. Then, the accumulated data will provide a solid foundation for further mobile application design development. Therefore, the thesis will focus on **3 key concepts**: (1) Smart City Technologies (SCTs) in urban planning, (2) gamification technologies for motivation, and (3) Playfulness and Augmented Reality (AR) as connectors between the environment and citizens.

The crucial research methods for the thesis include qualitative analysis as it would assist with an in-depth analysis of citizens' motivation, interests and concerns about the topics of sustainability and SCTs. These methods will include interviews, participatory research design, and evaluative surveys of the final product. The evaluation of a low-fidelity mobile application prototype will be needed to guarantee that it transmits the planned information and is user-friendly.

Through a quantitative method (surveys), the data on citizens perception of Smart Cities concept and their effect on sustainable development will be collected. Also, to provide a broader overview of a suggested topic and underline existing successful examples of smart cities, case studies will be integrated.

In the Table below, the research study framework is illustrated with 3 main key concepts of the thesis.

TABLE 2. Conceptual framework

Conceptual framework	References
Smart City Technologies (SCTs) in urban planning	(De Bem Machado et al., 2021; Ahvenniemi et al., 2017; Blasi et al., 2022; Finn, 2014; Hassan & Thibault, 22019; Nijholt, 2019; Okello & Akoko, 2023; Silva et al., 2018; Toli et al., 2020; Şanta, 2022; Gade, 2023)
Gamification technologies for motivation	(Yee, 2006; Wallius et al., 2021; Santos et al., 2021; Muehlhaus et al., 2022; Guillen et al., 2021; Galeote et al., 2022; Christodoulou et al., 2018; Alsawaier, 2018)
Playfulness and Augmented Reality (AR) as connectors between the environment and citizens	(Leorke, 2019; Leorke, 2020; Low et al., 2022; Watershed, 2016; Thibault, 2019; Thibault & Bujić, 2020; Paraschivoiu et al., 2022; Nijholt, 2019; Hello Lamp Post, 2018; Hassan & Thibault, 2019; Ferri et al., 2020)

Thus, the **research question** of the thesis is: how gamified technologies encourage citizens of Tampere to interact with sustainability concepts? The sub-question, of how AR application might inspire individuals to become aware of the environment around them will also be addressed.

3 METHODS AND PRELIMINARY DATA COLLECTION

The previous Chapter provided the reasoning for a chosen research direction, enforced by the current relevant studies questions and results. Thus, throughout the ideation and brainstorming sessions, it was decided to adopt **pragmatic** and **transformative** approaches in my research study as guiding frameworks.

Rather than focusing on one research perspective, I decided to implement mixed methods to observe and analyse the results of the work from different angles. Feilzer (2009) highlighted that the use of mixed methods in research provides more profound data gathered and combined from both research paradigms perspectives, so the results complement the missing ideas or showcase unexpected aspects.

As the pragmatic paradigm observes mostly questions appropriate to the research and focus point, the transformative paradigm adds interactiveness and might consider the contextual features of research participants (Mertens, 1997). Applied to this research study, and compared to the transformative paradigm, the pragmatic one aims to educate people on topics of smart cities and sustainability. This could have the potential to the mindset change of the target audience.

Since this thesis examines the possibilities of subtle behavioural change leveraging interaction through the mobile application, it is necessary to address the research from both paradigm perspectives. The used methods are described further.

3.1 Methods

To obtain sufficient and profound qualitative and quantitative data, I outlined applicable methods for this research study that may provide both relevant and unexpected results from the target audience. In total, **5 research methods** were used: researcher's diary (logbook), interviews, participatory design research (Design Jam workshop), low-fidelity prototyping, and evaluative questionnaire. The qualitative data was considered the prime one and its analysis required an understanding of the participants' cultural and academic backgrounds.

3.2 Logbook

The logbook method is associated with a pragmatic research framework (Ericsson, 2022). In the early stages of this study, the creation of the logbook was not an essential part of the research but throughout the one-year period of data collection, it contributed to the ideation process. In contrast to scientific logbooks that require precise dates and timing, the logbook that was used in the study consisted of notes from the meetings with stakeholders (e.g. HCI students, interviewees, and workshop attendees) and comments related to the discussed points. Figure 2 illustrates some of the extracts from the logbook that were taken during the data collection stage.
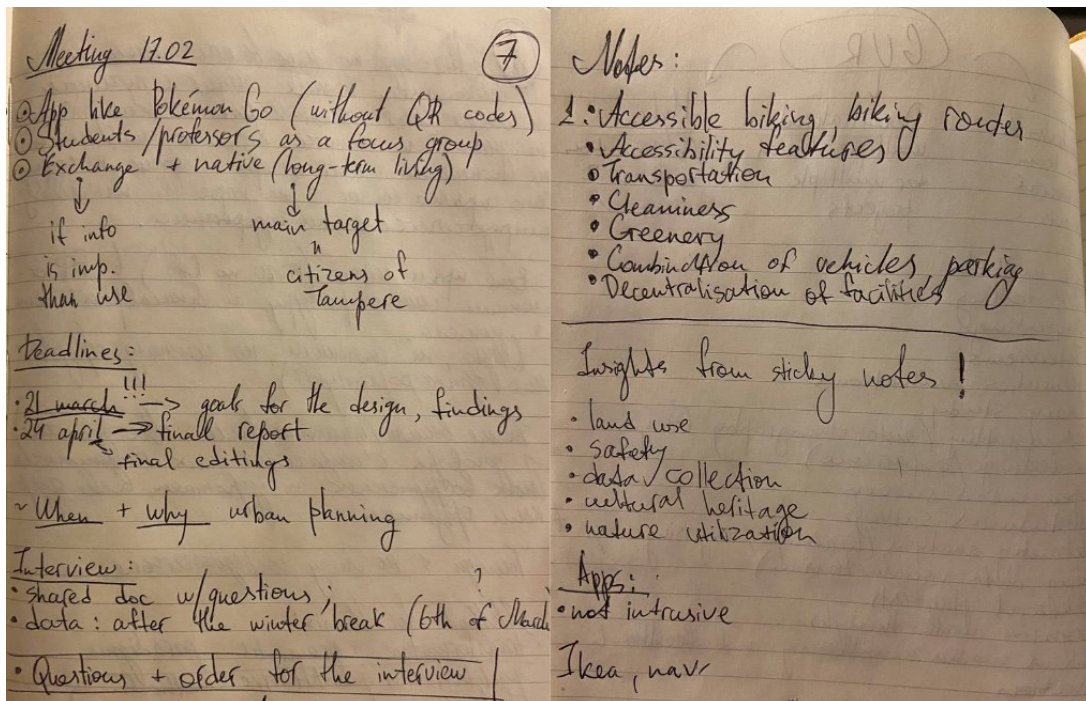
FIGURE 2. Notes from the logbook (researcher's diary)

The beneficial side of keeping a logbook for research that takes a long period is that it is possible to refer to comments and ideas that appeared during discussions and implement them into the next research stages. Additionally, it could assist the researcher with outlining the structure of the study and potentially highlight what has to be tweaked before proceeding forward. By keeping suggestions and analysing several possible research directions, one might narrow down the scope of the study and underline its focus.

As my research started collaboratively with students from the Human-Computer Interaction (HCI) programme, it was imperative for me to fix ideas in the logbook to develop them and/or apply them to my study direction. We held several team meetings and considered how we might carry out the research in a way that it would not interfere with the thesis work but provide supporting data and contribute to HCI students' course assignments at the same time. Therefore, keeping a logbook was necessary to document not only ideas but agreements as well.

3.3 Interviews

Jamshed (2014) defines qualitative research methods as an opportunity to obtain substantial knowledge of challenges related to the research topic by referring to contextual interpretations. Interviews in this case, as part of qualitative methodologies, supplement crucial to the study data with insights from interviewees not necessarily related to the research itself but crucial for future work. Interviewing the target audience was one of the crucial research methods to obtain necessary data for further research. Together with HCI students, we compiled possible questions that should be asked of interviewees, and we pinpointed once again the description of the target audience of the research study:

TABLE 3. Interviews' target audience

Characteristic	Answer
Age	Young adults (18-34 years old)
Place of residence	Tampere
Gender	Does not matter
Current status	Student or professor of TAU or TAMK
Background	International or local

The interview conduction is a multifaceted form of data collection that allows participants to freely express their ideas (Knott et al., 2022). Thus, one of the goals of interviewing the target group was to highlight possible peculiar ideas that would serve as guidance for the next research stages.

It is also worth mentioning that the focus of HCI students' study was to additionally understand how to engage citizens of Tampere in the city's development process. Therefore, it was essential for them to inquire about interviewees' opinions about services within the city and how they perceive the

connection between Smart City Technologies (SCTs) and the level of life in the urban setting. Figure 3 demonstrates the interview questions developed in collaboration with HCI students.

New Interview Questions – 08/03/2023

1. What facilities and services do you use in your city? (public transport, roads, libraries, public events etc)
    a. How often do you use them? (daily, once a week or more, once a month or more, once a year or more, rarely)
    b. Would you be interested to use any other services?
2. Do you think it's important to know about future developments in your city? Why?
3. How often do you engage in the decision-making process in the city you are living in?
    a. (follow-up if participant says no)
       Do you know how to engage in the decision-making process?
4. Have you missed any important information that you would have liked to have known?
    a. How did it affect you?
    b. (optional question if the person doesn't speak finnish)
       Have you encountered any situations where there's not been English as an available language?

Fasten your seatbelts, smart city theme incoming

5. How would you describe your perfect city?
6. Can you define what a 'smart city' is?
    a. (follow-up if unsure) Have you heard about the term "smart city"?
       Tampere is called smart city
       Sustainability, quality-of-life improvements, information flow,
7. On the scale from 1 to 10 how important is it to implement technologies in cities? Why?

Background questions

8. How old are you?
9. Do you live in the city center, suburbs or the countryside?

FIGURE 3. Interview questions from HCI students for citizens of Tampere

In a 2-weeks period, HCI students conducted 7 interviews (6 in-person and 1 remote via Zoom) with international and local students of Tampere University, and I could familiarise myself with their results. However, as all the interviews were held in an anonymous setting, it was impossible for me to define the necessary background information of interviewees apart from their approximate age. Nevertheless, the data that was collected provided relevant ideas and concerns of interview participants.

One of the most remarkable observations that should be recognised is that the 'smartness' of the city is defined by **technological development**, according to the interview participants. Technologies that were mentioned are digital billboards, electronic notification systems for citizens, personalised applications designed for residents of Tampere and an improved public transport system. At the same time, respondents mentioned the **uncertainty** they feel when discussing the topic of SCTs since the general definition of the Smart City concept is rather vague for them.

Another curious point that was mentioned is the **accessibility of city services**. For instance, interviewees highlighted that easy access to the services (e.g. transportation, public services,

entertainment, construction plans) could significantly contribute to citizens understanding of the processes around them, as well as engage residents in the city's life. Nevertheless, this discussion direction has led to several related issues that have made interview participants concerned. Firstly, the biggest issue that arose was the **lack of accessibility for international residents**. Most interviewees complained about the information distribution ways: important information was mainly shared in the Finnish language, making it almost inaccessible for English-speaking individuals. This plays a significant part in the disengagement of international residents of Tampere from the city's development and participation in community events.

The next problem that followed this discussion was **personal disappointment** in the quality of services. For some respondents, the services provided by the city did not meet their expectations, thus it has led to the general **indifference** to further the city's development processes. Therefore, interviewees mentioned that this also affected their motivation level to use Tampere's services, but they could reconsider their position if they saw a clear benefit for themselves.

Other discussion points included the level of interviewees' knowledge of the city's development plans (e.g. construction) and the ways to increase awareness of Tampere's building works.

Figure 4 demonstrates the thematic distribution of interviewees' answers on the Miro board.

FIGURE 4. Interviewees' answers gathered on the Miro board and distributed by themes

Next, it was imperative to determine the vision of the concept from Sitowise's side, as well as to discover possible research directions. For that, an interview with the Sustainability Consultant was held, another stakeholder of this study.

Since HCI students were mainly focusing on the process of decision-making engagement, I decided to create a bridge between SCTs and sustainability and urbanisation. Therefore, the purpose of the interview was to connect the concept of a Smart City and sustainable development within the city's environment. As Sitowise Oy is one of the major stakeholders of this research study it was imperative to include the company's ideas and opinions in the process of the project and thesis composition. This would ensure that the following work encompasses different perspectives and refers to the viewpoints that were made during interviews.

The interview with the Sustainability Consultant was conducted remotely and it was not anonymised. The interview was not recorded while the interviewee was informed that her answers would be used in future work development. The interview was designed in a way to incorporate several topics: a) the Smart City concept, b) sustainability, and c) citizens' awareness about the processes around them. Additionally, there were included ice-breaking questions so the interview participant would feel confident expressing her honest opinions.

Figure 5 illustrates the questions that were asked from the Sustainability Consultant during the interview.

INTERVIEW QUESTIONS FOR THE SUSTAINABILITY CONSULTANT

1. Can you please tell us about your work? What are your responsibilities?
2. Can you elaborate on the BREEAM certificate project? How is it connected to Tampere?
3. Can you briefly describe what characterizes a smart city?
4. What is the role of a smart city?
5. Do you see the connection between sustainability and smart cities? Why?
6. Do you think that smart cities bring citizens closer to nature?
7. What are the challenges of building smart and sustainable cities?
8. What, in your opinion, should citizens know about smart cities development?
9. Do you think it's important to let citizens decide how their city should be developed?
10. How well are you informed, as a citizen, about technological development in your city?
11. Do you think it is important to educate citizens on the topic of sustainability/sustainable development? Why?
12. Just a speculative question: how do you see the future of urban development?

FIGURE 5. Interview questions for the Sustainability Consultant of Sitowise

What outlined the following research process is the definition of a Smart City from the Sustainability Consultant's perspective. In her opinion, a Smart City is *'a city where citizens can effortlessly make sustainable life choices'*. Therefore, as the interviewee mentioned, the overall awareness of citizens about services that can improve their living conditions has to be raised as it is inextricably linked to the conscious behaviour and sustainable development of Tampere. At the same time, the focus should be transferred from a technology-driven perception of the concept, as it would assist residents of Tampere with developing a connection with the environment they live in. The more they understand other facets of sustainability the faster the transition to conscious lifestyles will be. The interviewee highlighted that the promotion of SCTs and their connection to sustainability should be targeted not only to adults but to children and youngsters as well.

During the interview, the challenges were also mentioned. For instance, as we proceeded, the Sustainability Consultant noted that apart from a general lack of knowledge about the development processes among citizens of Tampere, even the decision-makers mostly perceive the Smart City concept as predominantly related to technological advancements. However, it is crucial to **incorporate users' (citizens') needs** to improve the urban development. Also, they need to understand **what** is happening and, most importantly, **why** it is happening to mitigate the knowledge gaps about the concepts. Thus, by subtly adapting new practices into citizens' lives, it might be possible to enhance the transition of people's perception of their lifestyles and their attitude towards the environment they reside in. In the final phase of the interview, changes in legislation were mentioned as one of the aspects of the period of change. In the interviewees' opinion, Finland has the potential to set an example for other countries, therefore, it is imperative to increase the transition speed to sustainable lifestyles and education of citizens about the concepts.

After the interview was completed, some notes were taken in the logbook, and I proceeded with the ideation phase for my next research steps.

In Chapter 3, the preliminary research methods for data collection were introduced. In the next chapter, other research methods will be provided, which are participatory design research (Design Jam workshop), low-fidelity prototyping and evaluative questionnaire. As they require specific attention to the design of research actions and setting of the User Experience goals, the decision to divide methodological chapters into two parts was made.

4   PARTICIPATORY RESEARCH

The next stage of data collection is co-creation, i.e. participatory design research. The workshop organisation was one of the key methods of interaction with stakeholders and gathering insights. This Chapter provides the reasoning for the choice of this data collection method. Then, it proceeds with a description of the workshop preparation steps and measures taken to obtain relevant results. Following that, the Chapter illustrates the workshop flow, including activities and discussion points, and then the workshop results will be given as support for further research.

4.1 Co-creative workshop

The proposal to run a workshop was initiated by me hence I assumed that this could assist with data collection significantly. At the same time, the workshop results would not guarantee the exact desired outcomes relevant to the project but provide enough information to create an assumption-based product (Stickdorn et al., 2018). I was prepared to analyse the gathered data to enhance and evaluate my ideas for further development. The organisation of the workshop was an opportunity to test the preliminary suppositions I had and fix beneficial insights (Stickdorn et al., 2018).

The choice of this research method made me come to the conclusion that the flow of the creation process will follow the **Double Diamond diagram model**. As it is an iterative procedure, it was feasible to outline the course of both the workshop and the final product development that will proceed. The first part of the first Diamond, Discovery, would imply an establishment of the problem's understanding, and it will lead to the second stage of this Diamond: a clear definition of the problem. The second Diamond would start with the Ideation (Development) that includes the co-creation process, and then the Diamond would be finalised by the solution Delivery (Design Council, n.d.). The inclusion of facilitators and participants with diverse backgrounds would promote a fair and resultative discussion that would reinforce some of the ideas and help refine the outcomes.

Figure 6 illustrates the Double Diamond model.
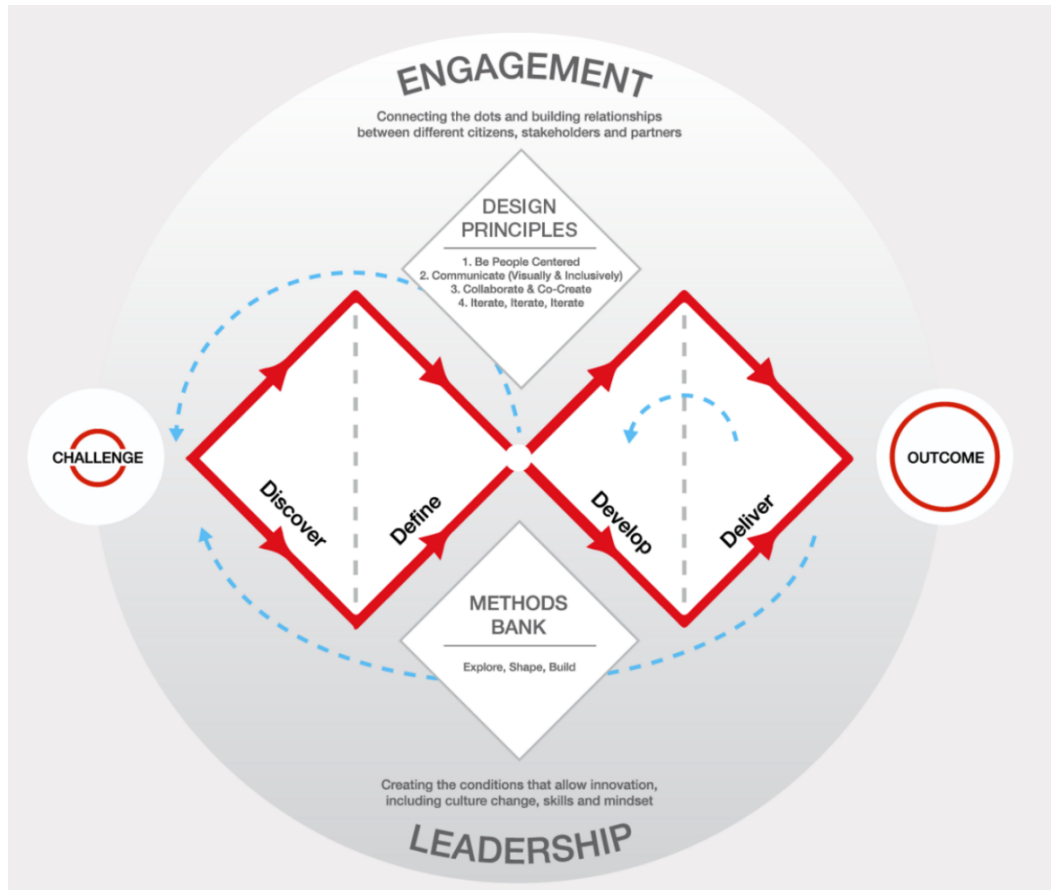
FIGURE 6. Double Diamond diagram (Design Council, n.d.)

In addition to the abovementioned statements, interaction with each other, inclusion of innovative proposals, and sharing thoughts would provoke a critical thinking process, allowing one to tweak their own or others' solutions, making to go back from the Delivery step to Development or Discovery.

Last but not least, I made a decision to run a workshop since it emphasises the participation of individuals who are highly engaged in the matter of discussion (Liu et al., 2023). Thus, the insights achieved throughout the workshop activities would be relevant for all stakeholders and minimise the number of insignificant pursuits in the following stage of the research. Furthermore, this approach underlines the importance of user-centred design by the involvement of target audience representatives in the design development process (Liu et al., 2023).

The idea of the workshop conduction was supported by the Sitowise manager and thesis supervisor.

4.2 Objectives

For this workshop, I underlined the following **objectives** that I intended to achieve throughout the whole process:

1. Discuss the concept of Smart City Technologies and highlight the relationship between the city' smartness and sustainability;

2. Build an affinity diagram to map the pain points of citizens regarding the city' development;

3. Observe successful projects of playfulness implementation to the city's environment to promote a serious topic;

4. Create paper low-fidelity prototypes of an application with Augmented Reality features to engage citizens in processes around them and subtly educate them.

Therefore, the preparation for the workshop development was based on the set of objectives and expected results.

4.3 Preparation process

Before the conduction of the actual workshop, it was imperative to not only prepare materials for participants but also approve them with the Sitowise representative and thesis supervisor. This would assist with the elimination of possible unnecessary actions and ensure that the results are applicable to the initial wicked problem of the project.

The preparation was divided into two stages. During the **first stage**, the draft material was produced that included the target audience description, essential materials for the workshop, a highlight of the workshop goal and steps, and a detailed agenda with timing. In addition, the preliminary version of the low-fidelity prototype template was made and a supporting material for ethical design was proposed. Figure 7 illustrates some of the draft materials from the first stage of the workshop preparation.

Frame 2

Target audience 5-10 people

Young adults (students of TAU): 18-30 y.o
- Education, background, gender, religion don't matter
- International + Finnish students

All the data will be anonymized and will not be recorded in audio/video format, but there will be taken pictures/screenshots during the workshop

Also: how to encourage people to participate?

Location: online/offline?

Frame 1

Workshop essentials

What is needed:

- template for the app (3-5 frames)
- post-its
- pens, markers, pencils
- canvases
- tape

if offline

- template for the app (3-4 frames)
- Teams/Zoom
- Miro/Figma/Mural

if online

Goal:

Make a low-fi prototype for an AR app that will show smart city's processes in Tampere and their impact on the environment + subtly educate its users (see Target audience) in an engaging way.

Description:

Participatory design research.
We will focus on the development of an AR app that will:
- show the smart city's processes of Tampere in Hiedenranta area
- visualise how they impact sustainable development in the city
- highlight the positive impact on the environment (emissions rate etc.)
- introduce 'small portions' of serious information in an engaging way for users.

The workshop will take approximately 1.5-2.5 hours.

Frame 3

Workshop agenda

Plan:

Introduction (5-10 min):
- goal
- timing
- instructions
- short description of Sitowise Oy

Warmup:
- getting to know each other (5 min)
- short discussion: how do people understand the concept of the 'smart city' --> collect the ideas on post-it notes and group them (5-10 min)
- we'll give a short description of the concept and highlight how technologies can not only improve the lives of citizens but benefit the environment (5-10 min)
- discussion of gamification technologies and the examples of AR applications. We will highlight how AR improves the experience and engagement of the user (Pokémon Go as an example) (5-10 min)
- discussion: what makes an application good? How can we improve the quality of the application? What students would like to see in the AR app that will be connected to the topic? (10-15 min)

Ideation:
- restating the goal (1 min)
- in the form of post-it notes we will ask students to write their brief ideas for the app and the desired features (5-10 min)
- discussion of the ideas: what are the similarities? What are the most important aspects of an AR application? (10 min)
- work with the template(s): we will ask participants to draw how they see an application for the project (in groups of 2-3 people). We will hand them the template for the application that will include: 1) 3-5 frames of the phone screen 2) text boxes for a brief description 3) text box for the unique feature(s) the app will have (30-40 min)
- presentation of the prototypes and discussion of the ideas (15-20 min)

Conclusion (5-10 min):
- recap of the workshop
- brief descriptions of the results and how they will contribute to the thesis
- questions (if any)
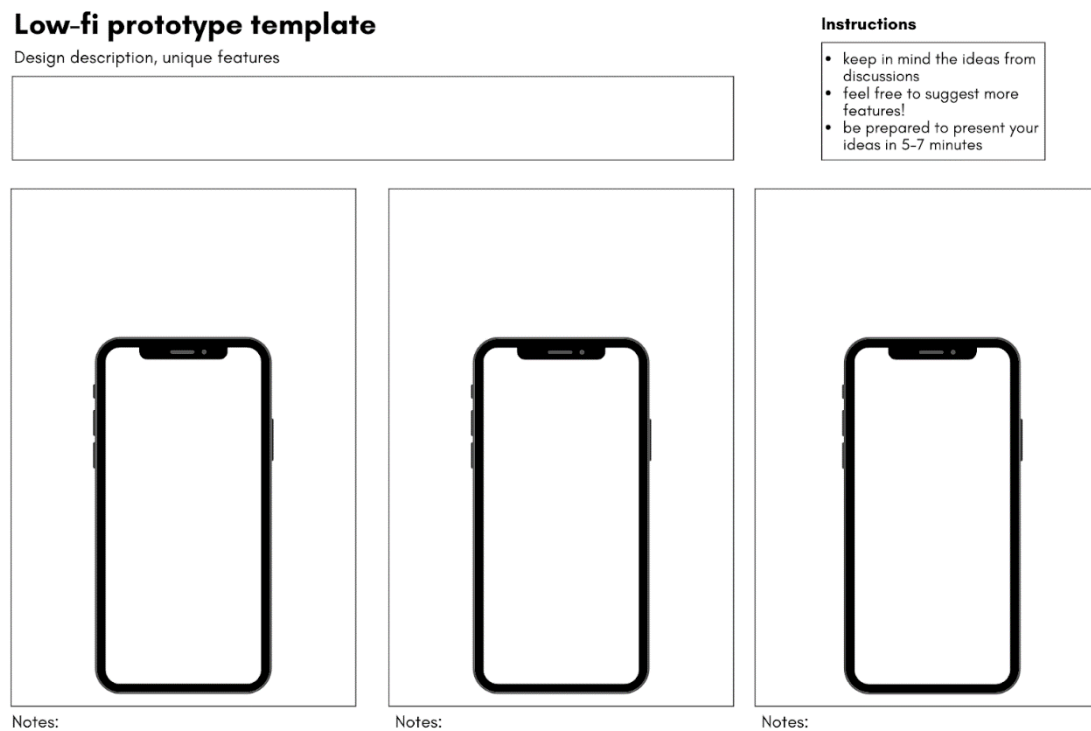- end of the workshop

1.5-2.5 hours

FIGURE 7. Part of the draft materials for the workshop made in Miro board

The reason why it was decided to include **ethics** in prototype development is to help participants critically approach the creation of a platform that includes the use of the personal data of users and aims to tweak individuals' perceptions of their surroundings. Ethics establish the acceptable borders of product development and secure social sustainability. Additionally, acknowledging aspects of ethics allows creators to consider their designs more profoundly.

Next, draft materials were sent for approval to the Sitowise representative and thesis supervisor, as well as other experts who could give their advice on workshop running. When I received the confirmation, the **second stage** of the preparation began.

This phase included the final materials organisation and search of participants. Figure 8 shows the final low-fidelity prototype template. With this template, participants could illustrate their suggestions for the application, showing details both on the screen of the phone and in the background (in the blank space behind the phone) which represents the real environment.

FIGURE 8. Low-fidelity prototype template for the workshop

As supporting material, I prepared a tool based on the Moral Value Map for ethical design. Thus, during the ideation and creation processes, participants could refer to it and reflect on the values and concerns that their design outlines. Considering this, attendees of the workshop could discuss how their final product affects users' perceptions of their apprehensions and highlight the key aspects of their application design.

Value and ethics
Based on the 'Moral value map'

Select values relevant to your design

Entertainment: Experiencing excitement or heightened arousal
Physical well-being: Feeling healthy, energetic or physically robust
Receiving: Obtaining approval, support or validation from others
Bodily sensations: Experiencing pleasure associated with the senses, physical movement or bodily contact
Exploration: Satisfying one's curiosity about personally meaningful events
Understanding: Gaining knowledge or making sense out of something
Positive self: Maintaining a sense of self-confidence, pride or self-worth
Transcendence: Experiencing optimal or extraordinary states of functioning

Harmony: Experiencing a profound sense of connectedness, harmony or oneness with people, nature or a greater power
Tranquility: Feeling relaxed and at ease
Belonging: Building or maintaining attachments, friendships, intimacy or a sense of community
Equity: Promoting fairness, justice, reciprocity or equality
Giving: Giving approval, support, assistance, advice or validation to others
Responsibility: Keeping interpersonal commitments, meeting social role obligations and conforming to social rules
Management: Maintaining order, organisation or productivity in daily life tasks

Creativity: Engaging in activities involving artistic expression or novel though
Safety: Being unharmed, physically secure and free from risk
Mastery: Meeting a challenging standard of achievement or improvement
Uniqueness: Feeling unique, special or different.
Autonomy: Experiencing a sense of freedom to act or make choices.
Superiority: Comparing favourably to others in terms of winning, status or success.
Intellectual stimulation: Engaging in activities involving original thinking or novel or interesting ideas

Possible concerns related to chosen values
e.g. AUTONOMY: 'I want to be in control of my actions while using the app'

How can your design affects these concerns?
e.g. the design reinforces/prevents/inhibits these concerns

What is the most crucial aspect of designing such an app? What is the most important feature?

FIGURE 9. Supporting tool based on the Moral Value Map for ethical design

The difference between this tool and the original Moral Value Map is that the original document focused on the deep analysis of ethical concerns and the contexts of use that affected certain values of a user (*Ethics for Designers — Moral Value Map*, n.d.). In contrast with the workshop material, this tool mostly requires profound discussions of possible disputes between stakeholders and issues that the design might or might not cause. The idea of the supporting material that was created for the workshop is to help attendees **concentrate on the values** of their prototype designs and narrow down the focus of their ideation process or inspire them to discover extraordinary solutions. Ethical concerns were also included in the tool but only to assist participants in considering every side of their ideas. Therefore, compared with the Moral Value Map, the main attention of this supporting material goes to the **valuable impact of design**, and possible ethical issues are not as deeply analysed but rather mentioned as a fact that should be overviewed in the future.

The official name of the workshop was '**Design JAM: Smart City Technologies & Application Prototyping**'. It was advisable to attract a minimum of 5 participants to collect the necessary data. However, the total number of attendees was 11 (4 females and 7 males): 9 Master's and 2 PhD students, all of them from Tampere University except for one person from Tampere

University of Applied Sciences. They were both local (2 individuals) and international (9 individuals) residents of Tampere. This allowed me to divide them into small groups of 2-3 people based on the background of the participants.

Appendix 1 provides the submission form for the participation in the workshop. From it, I was able to identify the general data about future attendees so I could understand the level of Smart City concept perception among them and if they developed a prototype before. The results were the following:

- 36.4% (4 people) had a background in **Design**;
- 27.3% (3 people) had a background in **Software Development**;
- 27.3% (3 people) had a background in **Social Sciences**;
- 9.1% (1 person) had a background in **Electrical and Electronic Engineering**.

Regarding familiarity with the Smart City concept and prototype development, people gave different answers:

- 72.7% (8 people) were **familiar with the concept** of Smart City, but they'd **never developed a prototype** before;
- 9.1% (1 person) were **familiar with the concept** of Smart City, and they **developed a prototype** before;
- 9.1% (1 person) **weren't familiar with the concept** of Smart City, but they **developed a prototype** before;
- 9.1% (1 person) **weren't familiar with the concept** of Smart City, and they'd **never developed a prototype** before.

These results assisted me in preparing for the workshop conduction. The date was set for the 20th of September, 2023, and it was held at the City Centre campus of Tampere University, in Digiport, Pinni B 4125.

4.4 Discussion & Co-creation Prototyping

The workshop was divided into 2 thematic parts. The first one, **Theoretical**, was discussion-based. During this part, participants were offered to learn more about the concept of Smart City Technologies and share their experiences in the city's environment and with mobile applications that include Augmented Reality features.

The beginning of the workshop was made in a way to make participants get to know each other to create a suitable environment for fruitful discussions and teamwork. The starting point of the

conversation covered attendees' apprehensions about the ideal urban environment that fosters comfortable living. Most of the participants stated that for them, a 'perfect' city should be:

- Accessible (including accessible biking with developed routes for easy access to different locations);
- Clean and green (e.g. with green public spaces);
- With a developed public transport system and the opportunity to combine different transportation modes;
- With decentralised facilities.

The initial attendees' perceptions of the Smart City concept were tested to engage them in a **brainstorming** session. To do this, they were offered to fix their ideas on post-its, and to subtly lead their thinking process I offered them to answer the following questions:

1. What makes a city sustainably developed for you?
2. What would you need to know about a sustainable city?
3. Are there any pitfalls/problems in designing smart cities?

Then, participants were asked to exchange their thoughts, and following this process, the **affinity diagram** was made. It assisted with highlighting possible pain points of Tampere's citizens. In the course of the activity, 7 main spheres of interest of participants were clearly defined. Other ideas were placed into a group without any particular theme. Additionally, it was possible to underline the concerns of citizens, as well as what they would like to know more about their surroundings and processes in Tampere. Table below provides the outcomes of affinity wall creation.

TABLE 4. Main spheres of interests and concerns of international and local Tampere residents

Culture	Nature	Safety	Public	Technology	Transportation	Resources
Inclusion of international culture in local	Inclusion and preservation of nature (and not its destruction) and accessibility	Policies	Attention to public opinions	User-friendly technologies within the city	Promotion of sustainable ways of travelling	Waste management and energy use
Careful implementation of new technologies in historical areas	Nature is valuable	Inclusion of all social groups	Accessible public spaces development	How digitalisation helps	Park-and-ride places	How the energy is used effectively

How to preserve cultural heritage	Nature is prioritized	Safe infrastructure creation	How to consider everyone's needs	Contribution of digital technologies to city's development	Car sharing	How to achieve sustainability with the limited resources of the city
Festivals and Art in the city	How to utilize nature without deteriorating it	How the data is collected	Changes in the existing population and how to make people practice sustainable actions	The cost of transition and implementation of new technologies		How to maintain wise resource consumption
Culture and nature shouldn't be separated, authenticity	How the land is for the city's needs	Concerns about personal data use	Anti-social policy			
Difficulties with a combination of old cultural heritage and new tech						

Moreover, there were suggestions without any specific theme but that also were covered while discussing the results:

- The willingness of the government to contribute to sustainable development;
- Solutionism mindset (sustainable and smart tech should be considered as the only solution);
- Average building's construction age;
- What are the methods of green transition;
- How to make the city not 'too futuristic'.

In Figure 10 the affinity diagram is presented.
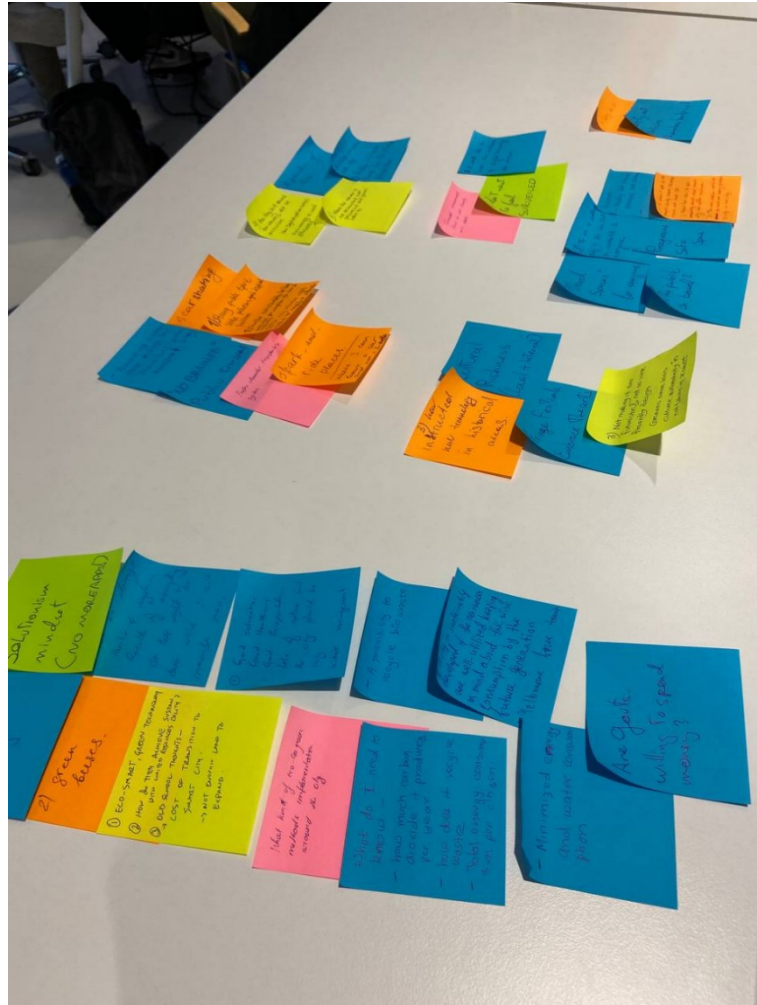
FIGURE 10. Affinity diagram

In addition to that, it was noticed that it was not challenging for participants to identify the concept of a Smart City. However, their attention was mostly on one aspect and they do not overview it as something that encompasses interconnected areas. For some respondents, it might be only related to technological advancements, while others say that a Smart City is 'a place with developed accessibility', and some people focus on environmental protection. When giving a definition of the concept, participants tended to give broad answers, thus they subconsciously understood what a Smart City is but did not have a definite answer.

Following that, it was important to provide the definition of 'Smart City' to mitigate any possible misunderstandings or prejudice that still might arise among attendees. Firstly, I introduced them to the explanation offered by the European Commission, but then I gave them another option that has found higher recognition among the participants due to its simplicity and personal resonance:

'***Smart City*** *is a city where people can effortlessly make sustainable choices*' (from the interview with a Sustainability Consultant from Sitowise). Concluding this point, we proceeded with a brief debate about the frequency of mobile applications used among the attendees that include AR features. As was evident, among international respondents the popularity of the Google Translator camera was dominant, fewer individuals mentioned Google Maps navigator, and only one participant mentioned the IKEA application that helps with the furniture purchase process. Another point of discussion highlighted attendees' unwillingness to engage in intrusive applications and/or that would give them a feeling of being surveilled. Mentioning the mobile application features that participants prefer or consider irrelevant was beneficial for the next part of the workshop.

Lastly, for this part of the workshop, I introduced participants to two successful projects of playfulness incorporation into the city's environment to promote the serious topic. The first one, URBANIMALS, illustrated opportunities to help people rediscover locations in their city and assist them in enhancing the feeling of presence in their surroundings (Watershed, 2016). The second project, Hello Lamp Post, followed several goals: 1) to track data from a certain point of the city that people shared during the interaction process, and 2) to engage people to know more about their surroundings and processes around them (Hello Lamp Post, 2018). To do so, the creators made ordinary objects of the urban environment alive in virtual reality and inspired citizens to partake in conversation with them. After analysing these projects, we proceeded further.

The second part, **Practical**, was dedicated to the **co-creation** process based on the discussion results from the Theoretical part of the workshop. Participants were offered paper templates and printed value tools to support their ideas. During this stage, people worked on the prototypes of mobile applications that might improve citizens' understanding of their environment.

Attendees of the workshop were divided into 5 diverse groups that ideally included 1 person with a background in Design, 1 person with a background in Social Sciences, and 1 person with a background in Software Development or Engineering. They were given detailed instructions on the workflow and the outcomes that had to be presented after a certain time limit (1 hour). Figure 11 presents the early discussion between group members about their application idea.
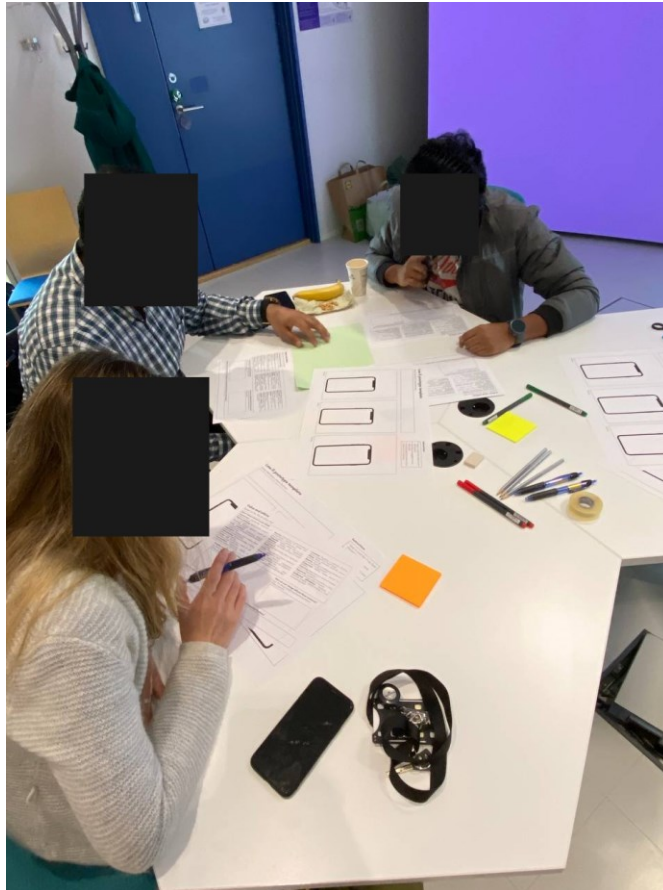
FIGURE 11. Discussion among group members (faces are hidden for ethical reasons)

While discussing important aspects of applications, the importance of inclusion into the decision-making process of people from different cultures and backgrounds and providing opportunities for citizens to connect with each other and make a collective input. Moreover, the role of accessibility and the incorporation of nature to foster citizens' responsibility level to their surroundings was also covered.

During the co-creation process, each of the groups focused on completely contrasting ideas but that included discussion points from the first part of the workshop. Group 1 aimed to create a platform for the exploration of the city with the possibility of interacting with other users and supporting local businesses. Additionally, it was the only group that mentioned monetization of the product. Group 2 mostly focused on the creation of connections between residents of the same buildings to promote social sustainability. Group 3 introduced an application that would allow users to explore the nature of Tampere and learn how to take care of the environment with the possibility of interacting with other people. Group 4 presented a prototype that would allow one to go back in the past and see how the city has developed throughout time with the possibility of observing how technologies improved

the quality of life. Group 5 targeted developing a platform that would introduce uses to the natural resources that Tampere has and how to consciously use them without harming the environment.

Figure 12 illustrates the final low-fidelity prototype development stage of one of the groups.

FIGURE 12. Finished the low-fidelity prototype of one of the groups

At the end, attendees of the workshop presented their prototypes and engaged in the discussion of each idea. Then, we outlined the benefits of Smart City Technologies' promotion and finalised the results of the workshop.

4.5 Results of the workshop

During the workshop facilitation, I examined curious patterns that occurred in the discussion and prototype creation processes:

1. People are striving for **communities creation**. Especially it was noticeable among international residents due to the feeling of loneliness they experience;

2. Participants did not focus on technological aspects while creating prototypes but rather on **environmental/natural** and **social sides**;

3. Attendees of the workshop wanted to **incorporate the cultural heritage** of the city into the discussion of Smart Cities;

4. Some similar aspects included: communication and **social interaction** (anonymous or not), assistance and support, collaborative contribution to sustainable development, different **locations exploration**, maintaining a safe environment for citizens (local and international), physical presence and **real-life activities**, and being a part of the city (so people are not detached from their surroundings).

Moreover, it was possible to examine application features that participants considered important for the application that would promote SCTs and educate citizens of Tampere on the topic. In Table 5 results are presented.

TABLE 5. Application features examined during the workshop

Application features	
Repetitive	**Unique**
Interactive map of the city/street	Points collection
Hints	AR interactive notice board
	Inclusion of the emotional aspect that would lead to building a feeling of responsibility by creating an emotional connection with the surroundings
	Demonstration of the location's appearance in the past with the comparison of how it was developed

The data gathered during the workshop would allow me to converge ideas that participants shared throughout the discussion and prototype development processes and outline the most relevant features. Based on that, I intended to create my own low-fidelity mobile application prototype with incorporated aspects of each of the 5 prototypes to evaluate the perception of functionality and goal of the application among the target audience of the project. Therefore, the next stage of the research began.
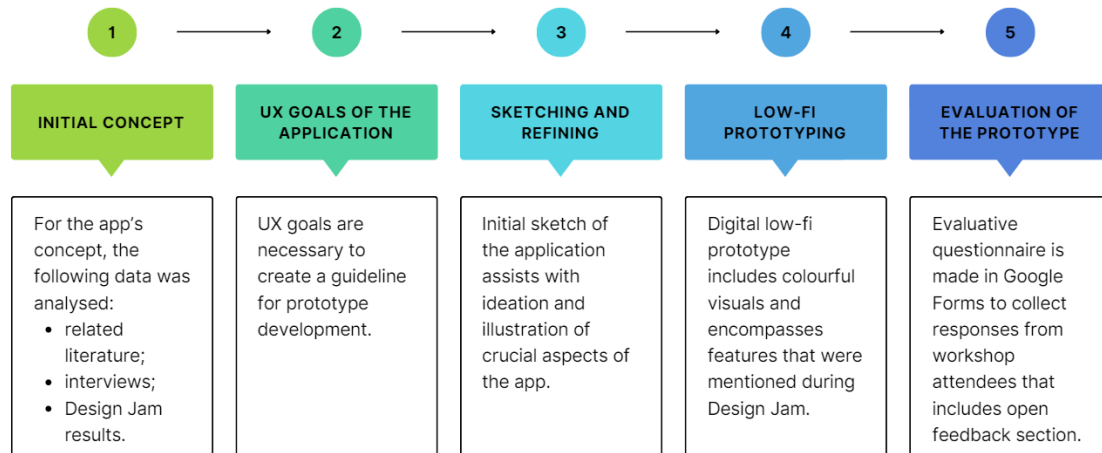
5 LOW-FIDELITY PROTOTYPE DESIGN

After an in-depth analysis of the discussion points and prototypes of each group, I aimed to develop a low-fidelity prototype of the mobile application that would introduce users to the concept of Smart City and subtly educate individuals on the topic of sustainability and conscious behaviour. To improve the motivational aspect, it was crucial to incorporate such features that would add value for users. In this Chapter, I propose the process of my own low-fidelity mobile application prototype creation, outlining the User Experience goals it targets. Then, the evaluation results are provided. The Chapter ends with the calculation of the application's rating.

Figure 13 outlines the final development steps that were taken after data collection needed for the low-fidelity mobile application prototype development. Overall, it included 5 steps that incorporated:

- Initial conceptualisation;
- Setting of User Experience goals for the application;
- Prototype sketch creation;
- Digital low-fidelity prototype development;
- Prototype evaluation.

Development steps

1 INITIAL CONCEPT	2 UX GOALS OF THE APPLICATION	3 SKETCHING AND REFINING	4 LOW-FI PROTOTYPING	5 EVALUATION OF THE PROTOTYPE
For the app's concept, the following data was analysed: • related literature; • interviews; • Design Jam results.	UX goals are necessary to create a guideline for prototype development.	Initial sketch of the application assists with ideation and illustration of crucial aspects of the app.	Digital low-fi prototype includes colourful visuals and encompasses features that were mentioned during Design Jam.	Evaluative questionnaire is made in Google Forms to collect responses from workshop attendees that includes open feedback section.

FIGURE 13. Final development steps

5.1 User Experience (UX) goals

Karvonen et al. (2012) argue that User Experience (UX) goals should serve as a guideline for the development process that would assist with the implementation of the necessary product' features. Based on the thematic touchpoints of the affinity diagram and values that were chosen the most from the supporting tool made for the co-creation process, I determined to set User Experience goals that the application will attempt to achieve. However, I did not have the inclination to make a solution that would incorporate each of the concerns or ideas proposed since it would overcomplicate and diminish not only the quality of the design but the applicableness of the entire product as well. Therefore, it was decided to select several touchpoints and values that would be logically appropriate to combine.

In addition, during the prototype creation, it was crucial to ensure that the initial set of UX goals was still identifiable while examining the application features (Karvonen et al., 2012). On that account, I underpinned the following UX goals for my low-fidelity prototype of the mobile application:

1. **Exploration:**
a. Possibility to discover locations in Tampere;
b. Easiness of interaction with AR objects;
c. Access to relevant data.
2. **Understanding:**

a. Learning opportunities in an accessible way;

b. Continuous educational interactivities.

3. Belonging:

a. Opportunity to join communities and social events;

b. Options to connect with other users;

c. Seeing collective input.

4. Responsibility:

a. Commit to rules to support the goal of the application;

b. Follow the instructions to maintain an efficient application process.

5. Autonomy:

a. Possibility to choose the mode of operation of the application;

b. Opportunities to make independent choices.

Setting the goals for the application features development assisted me with finding a certain focus to ideate a feasible proposal that would be beneficial for all stakeholders. Hence, I proceeded to the next step of the prototype development.

5.2 Prototyping stage

To explore ideas of the application' features visualisation, it was determined to make a pencil sketch of mobile application frames with possible contents. During the brainstorming, I outlined the gamification aspects as well as the educational aspects that must be depicted in the prototype to illustrate the value of the product. Thus, the next step was to pinpoint the exact features that could affect users' motivation to interact with the application and not stop the activity. In Figure 14, the pencil sketch of the prototype is shown.

FIGURE 14. Initial sketch of the low-fidelity mobile application prototype

As shown in the Figure above, this sketch includes most of the aspects that were discussed during the workshop. On the interactive map, the user can pick a certain task that he or she would want to accomplish, and then the application provides several options for how to travel to a certain point. Next, the user has to discover a virtual tip using the mobile camera in the application to complete the task and learn sustainability-related information. The completion of the task would lead to an experience increase and virtual currency obtaining. Thus, after finishing the tasks, it is possible to achieve a new level and plant a virtual tree in specific locations of Tampere. There, the user can discover sustainability-related events, participate in public polls and meet like-minded individuals via the AR notice board.

This sketch served as an initial guidance for completing a digital low-fidelity application prototype.

In addition to that, it was important to outline player-user typologies to make the development process clearer.

Player-user types allow creators to pinpoint the specifics of potential users' behaviours to foresee what kind of features might attract them the most and what should or should not be included in the final design. As was observed during the interviews and the workshop, the main driver of individuals' actions is intrinsic motivation. People are affected by their interests and goals to participate in sustainability-related activities and external factors only support their enthusiasm. Therefore, even though most of the player-user typologies are rather superficial and tend to oversimplify the reasons why individuals behave in a certain way, developers need to tailor their products to the needs of specific user types. Yet, the attention to typologies should be holistically approached with other research methods.

Yee (2006) outlined three groups (player motivation models) that depend on the specifics of users' goals for a game: Achievement, Social, and Immersion. These groups contain components that could be leading directions for game developers. For instance, people who have Social motivation tend to form relationships, collaborate with others and play in a team, so creators of the game can implement social affordances into the gameplay (Yee, 2006). Those with an Achievement motivation prefer to compete, improve their stats and collect badges. Users with Immersion motivation play the game for escapism purposes, and it is crucial for them to have customisation and exploration features (Yee, 2006).

For my application, I found that the inclusion of Social and Immersion motivations would foster a more sustainable and motivating environment for potential players. Achievements would be a part of the playing process as well; however, the emphasis will be on meeting like-minded people and participating in meaningful activities for the common good. Therefore, the prototyping stage proceeded with attention to features that both motivation groups would prefer to use while interacting with the application.

The idea of the application is to provide a personalised experience that would assist one in maintaining a conscious lifestyle, completing tasks and challenges and participating in public discussions and events. Figure 15 demonstrates the first 3 wireframes of the final design of the low-fidelity mobile application prototype. It was decided to choose a minimum number of colours and details to avoid misunderstandings and overstimulation that potential players might experience. Initially, the application starts with an introduction where the user can insert his or her name to start the personalisation process. Then, it allows one to create a simple profile where it would be doable to track virtual balance, level of the player, and number of friends. Personalised tasks would be

introduced to the user as well, and by completing them one can improve his or her sustainability scale and collect virtual currency.

Since the goal of the application is to provide educational materials to enhance the overall perception of sustainable development in Tampere, the user could explore sustainability tips (e.g. lists of local brands or public transport lines).
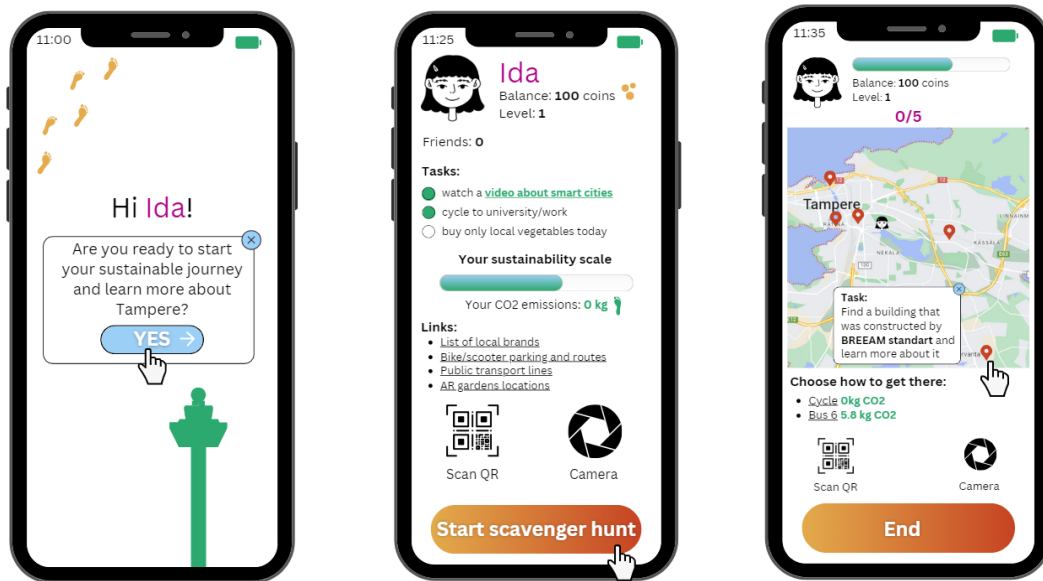
FIGURE 15. The first 3 wireframes of the final design of the low-fidelity mobile application prototype

To obtain more coins, the player can start the scavenger hunt, and to end the challenge, one has to complete all of the tasks from the interactive map of the city. Each of the missions includes educational tips, and they are placed in different locations in Tampere (including peculiar ones). In addition to that, it will be possible for a user to decide on the transportation methods as the application assists with the route choice as well.

Figure 16 illustrates the next 3 wireframes of the mobile application. When the player finds an AR hint, he or she has to interact with it to complete the task. There, it would be possible to learn something about Tampere and the concept of Smart City, along with the conscious behaviour and sustainability facets.
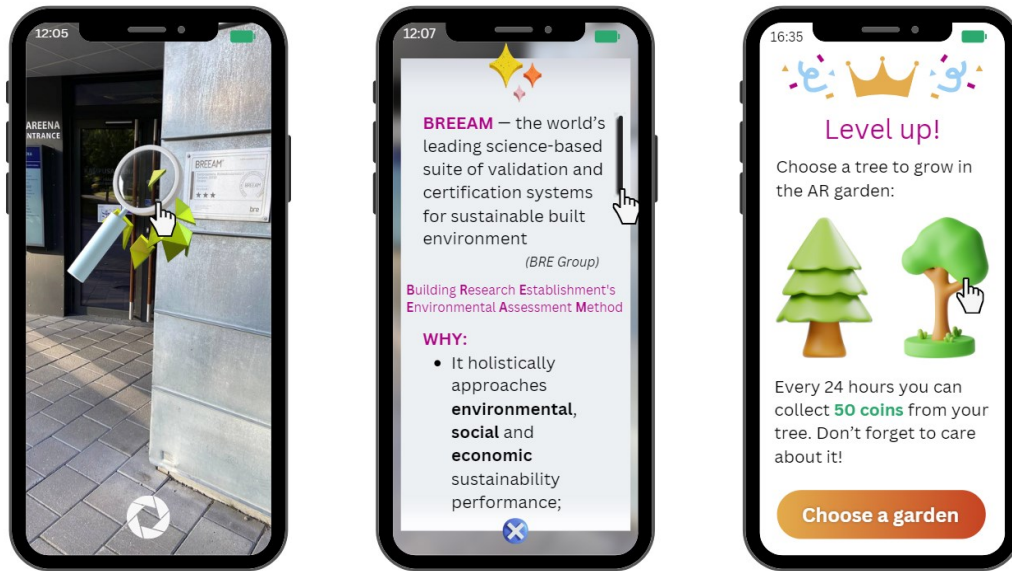
FIGURE 16. The next 3 wireframes of the final design of the low-fidelity mobile application prototype

By completing the task, the user obtains a certain amount of experience that would eventually lead to the level increase. After levelling up, the player receives a personal virtual (AR) tree that can be placed in one of the AR gardens located in different areas of Tampere. AR gardens are based in locations that lack greenery in their surroundings, thus, users can improve the scenery in the virtual environment. Nevertheless, the process of getting a personal tree does not mean the end of the activity, since it is imperative to take care of the AR tree for it to grow and 'bloom'.

Figure 17 provides the last 3 wireframes of the application. There, the illustration of the AR garden is shown with a demonstration of features that the user can interact with. For instance, apart from collecting virtual coins from the AR tree, it is feasible for the player to see the virtual (AR) notice board where one can explore events and volunteering opportunities in Tampere, see the location and dates of swaps, or participate in public polls and the decision-making. It is also allowed for the user to post his or her own publication, however, it must be moderated before being implemented into the system.
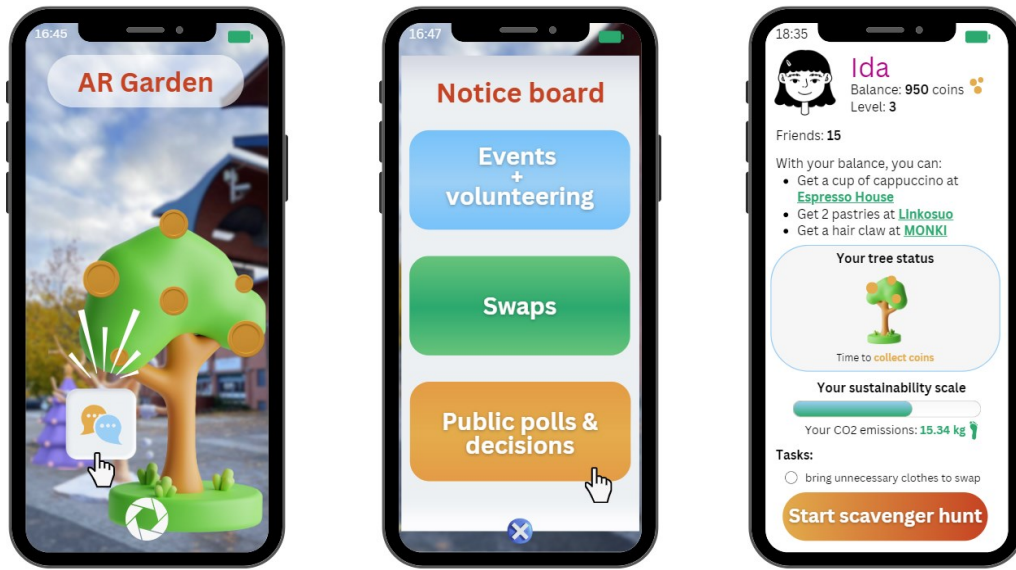
FIGURE 17. The last 3 wireframes of the final design of the low-fidelity mobile application prototype

Additionally, users will be encouraged to take pictures among the virtual greenery and share them on social media to raise awareness about the application. Last, but not least, the currency that players collect throughout their activities could be redeemed for real products from sponsors that support sustainable development. That could be cafes, small shops or independent creators. Thus, people could grow their network, learn, explore Tampere, and track their CO2 footprint.

After completing the wireframes of the final design of the low-fidelity mobile application prototype, it was crucial to validate my assumptions and collect feedback from participants of the workshop to outline if the UX goals were met.

5.3 Average rating of the application

To evaluate the developed low-fidelity mobile application prototype, the Google form was created. The feedback was collected anonymously, however, I requested participants to state their names for my own understanding of who submitted their responses and who did not.

In Appendix 2, it is possible for a reader to familiarise himself or herself with questions that were asked by workshop attendees. Some peculiar aspects that could be highlighted are presented next.

Although 36.4% of respondents stated that the overall application design seems average, it is noticeable that potential users give their favour to the opportunity to participate in daily tasks and

challenges due to the developed rewards system. Thus, these aspects refer to extrinsic motivation enhancement. In addition to that, sustainability tips and interaction with AR (e.g. AR trees and AR gardens) were evaluated high enough to conclude that people might want to expand their knowledge about sustainable behaviour and ways to improve their surroundings. Figure 18 demonstrates votes distribution among features participants found remarkable.
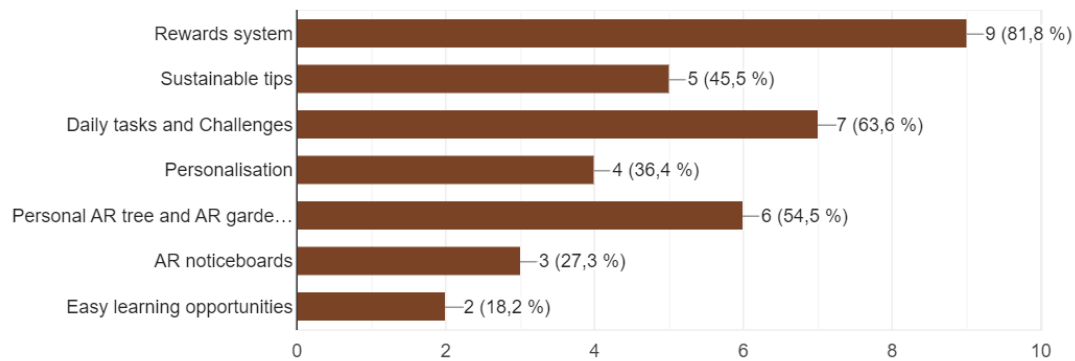
FIGURE 18. Votes distribution on the question about the best application feature(s)

Respondents were asked to provide a numeric evaluation (on a scale from 1 to 5) of the five application aspects based on the User Experience goals that were outlined before the application prototype creation. The results of this evaluation were rather satisfying and met my expectations:

- **The majority** of participants **(45.5%)** graded the statement that *'the application fosters communication and community creation'* as **4**, while **36.4%** gave the grade of **5** and **18.2%** graded it as **3**.

- **The majority** of participants **(63.6%)** gave a **5** mark to the statement that the application *'encourages to explore the city'*, while **36.4%** gave a grade of **4**.

- **An even number** of respondents **(36.4%)** gave marks of **4** and **5** to the statement that the application *'fosters the feeling of responsibility'*, while only **27.3%** graded it as **3**.

- **54.5%** of respondents gave a grade of **4** to the statement that the application *'helps to understand the concept of smart city and contribution of smart cities to sustainable development'*, while **36.4%** marked it as **5**, and only **9.1%** gave it a grade of **3**.

- As participants were asked to give an overall rating for the application, **the majority** of respondents **(45.5%)** gave it a grade of **5**, **36.4%** gave a mark of **4**, and 18.2% graded it as **3**.

Nevertheless, in addition to the abovementioned results, it was decided to give a conclusive average rating to highlight the final attitude of participants towards the application prototype. The formula that was used was:

$$(3 * n3 + 4 * n4 + 5 * n5)/(n3 + n4 + n5)$$

where:

n3 — a '3' grade

n4 — a '4' grade

n5 — a '5' grade

The average rating of the application was **4.3**. This result signifies that overall, respondents found features and the concept captivating, although it seemed to them that the way of executing tasks can be enhanced by adding a certain value for players. Subsequently, it can significantly contribute to the willingness of participants to use the application in the future if it is developed.

Yet, another quaint aspect that must not be overlooked by creators is ethics. Respondents noted some concerning application' features: 1) use of personal data, 2) use of camera, and 3) geolocation. The process of tracking and collecting users' information has to be transparent to avoid issues related to the safety and data protection of players. However, it is not enough to provide transparency but to ensure that personal data will not be transferred to other parties without users' consent.

6 FINDINGS AND DISCUSSION

This Chapter focuses on the analysis of the application development results. Then, it proceeds with remarkable findings that were highlighted throughout the research study and reflects on the research questions set in the beginning of the work. Next, the connection between previous concepts research is discussed, bridging them between each other and exploring the potential for future studies.

6.1 Analysis

Examination of results received during the evaluation phase, as well as aligning them with UX goals set before the application development allowed me to outline the feasibility of such an application creation. It is evident that it can be relevant to citizens of Tampere, especially international ones for several reasons.

Firstly, as foreigners may come from different cultures, they could educate themselves on the topic of sustainable development and playfully learn how to maintain a conscious and 'greener' lifestyle. In addition, they can get familiar with the Smart City concept and grasp how surrounding processes contribute to enhancing citizens' lives.

Next, people can form communities and bond through the application, participating in the city's events and polls. Moreover, players can virtually improve Tampere's surroundings by creating AR gardens that could foster one's feeling of responsibility and provide opportunities for social interaction as well. As was previously discussed in Chapter 2, such interventions could be applied to the DIY urban movement, however, with certain modifications. For instance, this approach will mitigate the critical feedback from the authorities as AR modifications of the surroundings still would be unauthorised but they will not intervene with the real-life processes.

Nevertheless, these impromptu activities could be still investigated by the city planners and other stakeholders and taken into account in future development projects. Additionally, these AR features may bring playability in urban environment, encouraging citizens to engage in fun activities (e.g. tasks completion) and explore their surroundings, critically approaching their design and suggesting possible opportunities to modify them. Therefore, this application could potentially bring

beneficial results to urban development of the city and subtly educate international and local residents on the topic of sustainable development.

Thus, it can be said that User Experience goals were met during the development phase and the feedback from respondents validated them. Hence, if the application is ever created, developers should consider ethical concerns and design drawbacks mentioned by participants to provide a better product and create value for users.

6.2 Findings

For this research study, it was crucial to identify general knowledge of the Smart City concept among citizens of Tampere and examine how to encourage them to learn more about it with the use of playful AR technology. The conducted work has allowed me to outline the answers to the research question and the sub-question.

The research question: how gamified technologies encourage citizens of Tampere to interact with sustainability concepts?
During the Design Jam workshop, attendees demonstrated a high level of interest in sustainability topics and how their actions can contribute to the development of their surroundings. Overall, the workshop participants were excited about the use of gamified technologies to explore the city and, most importantly, build communities and make new valuable connections with other people. In addition, the main motivational factor to use the mobile application would be points collection which would lead to unlocking new achievements and receiving rewards.

Both local and international residents of Tampere stated the significance of participation in real-life activities in the city so they would not feel detached from their surroundings. Moreover, attendees mentioned that in the game that would promote sustainability concepts, they would want to have the opportunity to do collaborative actions. Thus, it would demonstrate public interest in the city's development, build communities and allow people to learn about sustainability from each other, sharing their experiences.

The sub-question: how AR application might inspire individuals to become aware of the environment around them?
The discussion that was held at the Design Jam workshop outlined that AR technologies are not much used among participants but if they had an application that would bring value to the adoption of AR, attendees would use it on a daily basis. In addition, participants mentioned that an application

with AR features should be accessible and inclusive to all users, especially if it is aimed at the promotion of serious topics such as sustainability.

In attendees' opinion, AR technologies in such an application might build a connection between a user and his or her surroundings as it detailly demonstrates one's contribution to the environment. During the development stage of the low-fidelity mobile application prototype, the feature of building AR gardens was incorporated. As participants mentioned, it could assist in the building of the responsibility level of users since they become in charge of their trees' growth. Additionally, AR features might encourage users to explore their environment more carefully, especially when they are completing the in-app tasks and scouting for possible hidden virtual hints.

Apart from these findings, the conceptualisation Chapter demonstrated the growing interest of decision-makers, city planners and academics in the use of playfulness and gamification to improve the level of citizens' participation in urban development. The study illustrated that novel technologies such as AR could be implemented in residents' daily lives to 1) subtly educate them by providing information in an accessible way, and 2) build a connection and the feeling of responsibility to their surroundings. Therefore, this thesis aims to provide an example of the potential use of AR technologies in a mobile application that would improve the general knowledge of Tampere's citizens related to the topic of sustainability and meet the desires of potential users that were mentioned in the User Experience goals.

Throughout different stages of the research, it was possible to extract quaint ideas and opinions from study attendees. For instance, individuals honestly responded that the concept of a Smart City seems to be approached one-sided, therefore, people understand it as something related only to technology. Therefore, the lack of accessible information on the topic creates indifference and misunderstandings. Most importantly, when decision-makers do not fully comprehend the concept, they cannot meet citizens' needs and fail to create such an urban environment, where citizens can feel the connection between them and the place they reside in. Henceforth, these findings should be considered in future research.

6.3 Discussion

During this study, it was imperative to understand the general attitude of the target audience to the sustainability concepts and their knowledge of technologies that could enhance people's lives and mitigate the negative consequences of their actions. The idea of the research aligned with the interests

of academics in building connections between individuals and their surroundings as well as playfully encouraging them to act responsibly and participate in urban planning.

For instance, Low et al. (2022) investigated how pla(y)cemaking assists users of mobile applications to connect artefacts from the virtual environment with the physical world. In their opinion, by allowing users to participate in meaningful activities in locative games it is feasible to foster community creation and cultivate cultural heritage in digital dimensions. Collaborative actions and ownership of virtual items that are linked to the real world in a certain way might improve the level of responsibility of users (Low et al., 2022). The research conducted for this thesis supported this hypothesis and provided additional aspects that could be used in future studies.

Another noticeable idea was mentioned by Leorke (2019) regarding bridging the concept of Smart City and playfulness. As Smart Cities are perceived as technologically advanced places, the concern of adding opportunities for citizens from different cultural backgrounds to share their opinions and creatively participate in urban development is widely discussed (Leorke, 2019). Moreover, mitigation of the gap between playful interactions within the city and SCTs could provide more options for future urbanisation plans and add accessibility. In the thesis, the notion of bridging both concepts was reinforced by the proposal of creating a mobile application with AR features to assist citizens of Tampere to playfully learn about the Smart City concept and sustainability, participate in social activities and create virtual personal artefacts within the city as well.

This Chapter incorporated the evaluation of the low-fidelity mobile application prototype, reflecting on the User Experience goals that were set in the beginning of the development process, as well as mentioning consideration of respondents. Additionally, the findings of the conceptualisation and design development stages were summarized. I reflected on the research question and sub-question that I stated at the beginning of the research study. Next, I will proceed with the ethical aspects of the study and its credibility.

7 EVALUATION OF THE STUDY AND ETHICS

This Chapter provides an overview of the credibility of the thesis and makes an emphasis on ethical aspects of each interaction with interview participants or workshop attendees. Additionally, I reflect on the research question and sub-question that I stated at the beginning of the research study.

The qualitative research method requires additional attention to its design. Generally, participants might face unstructured data as the nature of these types of methods is flexible and adaptable to changing circumstances (Hammersley & Traianou, 2012). Moreover, according to Hammersley and Traianou (2012), in contrast to qualitative research methods where participants are limited by the boundaries set by researchers, qualitative research methods allow them to have a glimpse of personalities and lives of study's attendees, obtaining more information from them.

7.1 Credibility of the study

Apart from research ethics, it outlined the necessity to ensure that the research is reliable and trustworthy, and it could be used by other academics for their work. Thus, to ensure research credibility, a set of measures was taken into consideration during the whole study preparation.

Firstly, the consent from research attendees has established a solid foundation for further work and guaranteed participants their autonomy (Hammersley & Traianou, 2012). Next, as was previously discussed in Chapter 3, the research was designed for individuals with diverse cultural and academic backgrounds not only to collect more data but also to create an inclusive and respectful environment, where attendees could exchange their opinions and work collaboratively. The attraction of people with different life experiences allowed me to gain valuable insights and observe the research from various perspectives.

Chapters 4 and 5 extensively focus on data collection methods for the main stages of the study. Accumulated materials and the findings connect the analysis of concepts provided in Chapter 2, demonstrating the confirmability of the research. Additionally, as qualitative methods set a relatively adaptable study setting, it allowed me to maintain the objectivity of the research.

Lastly, this study referred to previous research and concepts as was thoroughly demonstrated in Chapter 2. It was imperative to constantly validate the correlation between data collection and outline gaps in preceding studies, and Chapter 6 contemplates the findings, aligning them with discussion points for future research.

The abovementioned measures secured trustworthiness of the study.

7.2 Ethical aspects of the study

Since this research study was conducted in several stages at different time periods (Spring Semester of 2023 and Autumn Semester of 2023), it was crucial to mitigate any possible ethical issues that might have arisen and protect participants' personal data. For that, a number of measures were taken to eliminate ethical concerns during each of the research methods.

The data collection process was designed according to both GDPR law and ethical standards fixed in the CO:RE Knowledge Base. Participants of all research stages gave their informed consent for their responses to be used in the study. The responses that they shared were not used in any other activity apart from the research, and transparency and extent of the personal data usage could be monitored by respondents. In this type of study, it is imperative to specifically highlight the reasons why and how the personal data will be used, thus, the focus of research was to guarantee its participants privacy and fairness (*General Data Protection Regulation (GDPR) – Official Legal Text*, 2022). Nevertheless, for each part of the research, it was imperative to consider distinctive ethical aspects of interaction and data collection.

This research followed ethical principles, avoiding discrimination, and securing honesty and respect to its participants (*Compass for Research Ethics*, 2022). Participation in any stage of the data collection was voluntary, and Appendix 1 and Appendix 2 provide examples of consent forms sent to potential attendees of the study. These forms were made following ethical standards, which include explicit descriptions of the research stage, and underlining what information will be documented and how (*Compass for Research Ethics*, 2022). Other examples of ethical principles during the study are listed below.

Ethics during interviews with HCI students

Students from the HCI programme conducted interviews both online via Zoom and offline in a face-to-face setting. Therefore, the ethical concerns could have been different for participants who were interviewed remotely since these sessions were recorded and saved in a Cloud service. However,

online participants were instructed that the data they shared would be anonymised, and the recordings would be deleted by the end of the Spring Semester.

Face-to-face interviews were anonymised as well, and the names of interviewees were replaced by a specific unique number.

Ethics during the interview with the Sustainability Consultant from Sitowise

The interview with the Sustainability Consultant was held online, and apart from me, there were 5 more attendees including the project supervisor from Sitowise's side. Even though the interview was conducted remotely, there was no need to record the video or voice of the interviewee. Responses that the Sustainability Consultant provided were written down and the fact that some replies would be noted was mentioned before the start of the interview. The name of the interviewee was also classified.

Ethics during the workshop

Participation in the workshop requires one to be prepared for all the possible ways of data collection. To prepare attendees for this, I tried to envision probable concerns that they might have to make the data collection process fair and transparent. Thus, in the registration form, I stated that the personal data of participants would be anonymised, and when photographic materials were taken the faces of attendees would be covered/blurred. I informed the participants of my research goals and how I would use the information gathered throughout the workshop.

As my study required, I included attendees of different ages, genders, and backgrounds to ensure inclusivity and foster profound discussions. All members of the workshop were treated equally and non-discriminative, and the information that was presented to them was designed according to accessibility guidelines.

The evaluation of low-fidelity application prototype was also conducted anonymously.

8   CONCLUSIONS

8.1 Summary

This research explored the potential of mobile application development with AR features to encourage the citizens of Tampere to learn about SCTs and sustainability. Additionally, the study focused on fostering the responsibility level of individuals to their surroundings by motivating them to participate in social activities via in-app tasks and cultivating virtual trees.

Preceding academic studies contributed to establishing the gaps in the research and provided opportunities for connecting the concepts with each other. Qualitative research methods were chosen to obtain profound information from study participants. Preliminary data collection assisted with exploring the focus of the research and outlined the trajectory of the following steps. During this stage, it was possible to estimate the initial knowledge of the target audience of the research topic and fix the discussion points for the workshop preparation. The quaint observation was made that individuals understand the Smart City concept as mostly technologically advanced urban development and the societal aspect was neglected from the consideration. The interview with the Sustainability Consultant from Sitowise gave input to the main idea creation of the future discussion and application design development.

The results of the work outlined the high interest among international and local residents of Tampere in sustainability concepts and what enhances the quality of people's lives within the city. Moreover, the Design Jam workshop provided valuable insights related to the concerns and desires of citizens regarding urban development. The feeling of disconnection between the city and other residents prevailed in the discourse, highlighting the feeling of isolation and loneliness especially among the international community. The low-fidelity prototype of the mobile application was created to eliminate the concerns mentioned by the participants of the study and to educate them on the topics of SCTs and sustainability, allowing them to collaboratively contribute to Tampere's development and playfully tweak their surroundings in the virtual environment.

This study proposed the design for a possible mobile application and incorporated key features relevant to potential users based on the outlined UX goals. Based on the research findings, suggested ideas, and limitations it is possible to conduct further studies to explore the potential of given results on a bigger scale.

8.2 Implications

The results of this thesis established a foundation for recommendations that academics can refer to. As the work demonstrated, the interest in the development of sustainable urban environments among various stakeholders (academics, urban developers, decision-makers, citizens) is increasing. Therefore, it is crucial to take measures that would assist with the following research steps.

First and foremost, the mitigation of the knowledge gap on the topics is essential. All parties should understand what SCTs are, how they contribute to sustainable urban planning, why society needs them and how they improve the quality of life. Thus, all these aspects should be actively promoted to increase the awareness of SCTs and their beneficence.

Next, future studies must be supported by the founding bodies. This type of research is crucial not only for scholars but also for governmental structures and institutions. The data and insights collected from relevant studies may assist stakeholders in their decision-making processes, but the funds are necessary to support academics in their endeavors.

To proceed with their work, scholars should have access to up-to-date information from parties involved with urban development. The exchange of data among stakeholders is essential for achieving necessary and credible results. Academics need to operate with information relevant to their proceedings. However, it is important to note that to ensure the safety of confidential data additional measures should be taken, e.g. non-disclosure agreements.

Also, decision-makers such as governmental structures should assist scholars with engaging citizens in research participation. This would guarantee that the data collected during studies would be profound, incorporating results from individuals from different cultures, with diverse backgrounds and interests. Such an approach would make the research inclusive, fair, and accessible.

8.3 Future work and limitations

Collected data from the conducted research could be used in future works and provide different study perspectives for academics. Nevertheless, there are certain limitations that should be considered by scholars and other stakeholders interested in the results of the research:

- **Participants:**

The number of research attendees was relatively small to provide in-depth results of this study. In future, it is crucial to attract a more extensive number of participants and analyse their backgrounds, socioeconomic aspects and level of education to obtain valuable insights and tweak the recommendations for the application development.

- **Companies' commitment:**

As different companies and organisations are the stakeholders of mobile application creation, it is important to examine their willingness to contribute to the education of citizens as well as share their data with a wider audience. In this case, the owners of these organisations should be aware of the benefits for their companies and the long-term results of this venture.

- **Ethical concerns:**

One of the key directions of the research should be aimed at ethics, focusing on GDPR and TENK regulations. Transparency of data use and distribution is predominant during each stage of research and application development.

- **Application features and design:**

In addition, after further research stages, the design and features of the mobile application might be transformed to improve the UX and UI.

This thesis can be used in future research related to the exploration of engagement opportunities for citizens with their urban environment. The results of this study provide valuable data regarding the concerns and desires of residents of Tampere and highlight how playful AR interactions in the urban setting can increase the interest of users in their surroundings. Additionally, the thesis examines AR mobile application features that could be developed to playfully educate individuals and motivate them to proceed with the game.

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10   APPENDICES

10.1 Appendix 1. Submission form for the participation in the workshop

Hi! Thank you for your interest in the workshop.

Please, read the instructions below:

During this **Design JAM**, we'll cover the main technologies of smart cities and how they contribute to sustainable development. Also, there'll be a short discussion related to AR applications, and we'll brainstorm how the serious topic of **SCT*** can be promoted to young adults with the help of AR.

Lastly, you will be asked to 'develop' a low-fidelity paper prototype for the app :)

*SCT - Smart City Technologies

Notice! The data gathered throughout the workshop will be anonymous **with the exception** of videos and photos that will be recorded to document the workshop process (without exposing participants' faces). Also, you will be asked to fill out post-survey to give your feedback after I complete my own prototype of the application.

IMPORTANT

Date: 20.09.2023

Duration: 2.5-3 hours

Start: 11.00

Food and **refreshments** are provided. In case you have **dietary restrictions**, state it in the last question of the form.

Thank you again and stay tuned!

1. What is your current education level?
- Bachelor's
- Master's
- PhD
- Other: _____
2. What is your university?

- Tampere University
- Tampere University of Applied Sciences
- Other: _____

3. What is your educational background?

- Design
- Urban Development/Architecture
- Software development
- Social Sciences
- Other: _____

4. Are you familiar with the concept of smart city, and have you ever developed a prototype of the application?

- Yes, I'm familiar with the concept, and I've developed a prototype before
- Yes, I'm familiar with the concept, but I've never developed a prototype before
- No, I'm not familiar with the concept, but I've developed a prototype before
- No, I'm not familiar with the concept, and I've never developed a prototype before
- Other: _____

5. What is your age?

6. What is your name (*you can write only the first name*)?

7. Please, write your email address (*for communication and post-survey purposes*)

8. Do you have food allergies that we should be aware of?

10.2 Appendix 2. Evaluative questionnaire for workshop attendees

Hi,

Thank you once again for participating in the workshop **'Design JAM: Smart City Technologies & Application Prototyping'**. Your answers and prototypes gave me quite a lot of insights which I used in my further work.

Now, as promised, I will ask you to **evaluate my own low-fidelity prototype** that I made **based on some of the points** that you made during our discussions. Please, see the prototype and description through this link: *https://www.canva.com/design/DAFxOYsbmIc/vxMNapuYbG3QIcw08pekjA/view?utm_content =DAFxOYsbmIc&utm_campaign=designshare&utm_medium=link&utm_source=editor*

After examining the prototype, fill in this short feedback form.

Thank you once again and feel free to reach out if you have any questions.

— Ana

1. Please, indicate your name (this is for me to track who completed the evaluation)
2. Was it easy to understand **the concept** of the app?

- Yes
- No
- I missed the point

3. What do you think about app's **design**?

- It looks great
- It is average
- I don't like it

4. Which features of the app are **the best** in your opinion?

- Rewards system
- Sustainable tips
- Daily tasks and Challenges
- Personalisation
- Personal AR tree and AR gardens
- AR noticeboards
- Easy learning opportunities
- Other: _____

5. Which features are **the most concerning**?

- Geolocation
- Use of personal data
- Use of camera
- Other: _____

6. On a scale from 1 to 5, how do you think the app fosters **communication and community creation**? (*where 1 = 'it doesn't help at all' and 5 = 'it provides a lot of opportunities to meet people'*)

7. On a scale from 1 to 5, how do you think the app **encourages to explore the city**? (*where 1 = 'it doesn't help at all' and 5 = 'it is really motivational'*)

8. On a scale from 1 to 5, how do you think the app fosters the **feeling of responsibility**? (*where 1 = 'it doesn't help at all' and 5 = 'it helps to be more attentive to the environment'*)

9. On a scale from 1 to 5, how do you think the app helps to understand **the concept of smart city and contribution of smart cities to sustainable development**? (*where 1 = 'it doesn't help at all' and 5 = 'provides a lot of information related to it'*)

10. On a scale from 1 to 5, what is your **general rating** for the application (*where 1 = 'it is useless' and 5 = 'it promotes sustainable actions and helps to make connections'*)

11. Would you use this app?

- Yes

- Maybe

- No

12. If you have **any comments**, please write them here: