



# MASTERARBEIT | MASTER'S THESIS

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WastelessWizard.IO - An application promoting the reduction of  
consumption of household waste

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## Abstract

The following master thesis aims to provide a solution to the global problem of mass consumption of waste in each household. Household waste certainly and significantly contributes to pollution and environmental issues, as residents consume too much packages foods and beverages, toxic chemicals and single plastic products. The world is facing more and more the consequences of pollution, enormous amounts of waste and global warming by having low amounts of snow in the mountains during winter, glaciers melting, waste polluted oceans, animals going extinct and many more. As a target solution, this master study is recommending a cross-platform mobile application which would make the users engage with it by providing human-computer interaction principles, as well as help them build healthier habits through several habit formation techniques. The cross-platform mobile application would calculate the daily waste output, recommend eco-friendly packaging alternatives and provide meaningful knowledge of materials so users can adopt and build sustainable habits. The target audience and users are people living in the city of Vienna. The users after making a profile in the application, can log the products which they bought from their daily grocery list, monitor their calculated metrics over time, get tips and tricks regarding more sustainable packaging and eco-friendly stores across the city, as well as gain points and learn more about the global issues contributing to global warming. With its user-friendly design, the application would serve as a practical solution to the users which want to make a positive impact in the environment and actually make a difference in the battle against global waste pollution. The change lies deep inside and it starts with each and every one of us. The master thesis further on explores how the engagement with waste tracking on a daily basis can help in the creation of positive habits, encourage users to make eco-conscious decisions and finally give the users an achievement feeling that they are helping and contributing the greater good of the planet. The results from the research show that the master thesis highlights the benefit of using digital tools in the fight of global environmental problems and inspire proactive daily waste reduction, which proves the application is providing a solution of the research problem. Additionally, the research is affirming that once the users are engaged and get a feeling of contribution, they influence the community to collectively contribute in the reduction of waste and promote a cleaner environment. What remains to be done as future enhancements would be to enlarge the market so other Austrian cities would be included, partner with local recycling initiatives to promote long-term waste reduction and launch the application globally.

## Abstract

Die folgende Masterarbeit zielt darauf ab, eine Lösung für das globale Problem des Massenkonsums von Abfall in jedem Haushalt zu finden. Haushaltsabfälle tragen zweifellos und erheblich zur Umweltverschmutzung und zu Umweltproblemen bei, da die Bewohner zu viele verpackte Lebensmittel und Getränke, giftige Chemikalien und einzelne Kunststoffprodukte verbrauchen. Die Welt sieht sich immer stärker mit den Folgen von Umweltverschmutzung, enormen Abfallmengen und globaler Erwärmung konfrontiert, indem im Winter wenig Schnee in den Bergen liegt, Gletscher schmelzen, Müll die Ozeane verschmutzt, Tiere aussterben und vieles mehr. Als Ziellösung empfiehlt diese Masterarbeit eine plattformübergreifende mobile Anwendung, die die Benutzer durch die Bereitstellung von Prinzipien der Mensch-Computer-Interaktion einbezieht und ihnen durch verschiedene Gewohnheitsbildungstechniken hilft, gesündere Gewohnheiten aufzubauen. Die plattformübergreifende mobile Anwendung berechnet den täglichen Abfallausstoß, empfiehlt umweltfreundliche Verpackungsalternativen und bietet aussagekräftiges Materialwissen, damit Benutzer nachhaltige Gewohnheiten annehmen und aufbauen können. Die Zielgruppe und Benutzer sind Menschen, die in der Stadt Wien leben. Nachdem die Benutzer in der Anwendung ein Profil erstellt haben, können sie die Produkte protokollieren, die sie von ihrer täglichen Einkaufsliste gekauft haben, ihre berechneten Kennzahlen im Laufe der Zeit überwachen, Tipps und Tricks zu nachhaltigeren Verpackungen und umweltfreundlichen Geschäften in der ganzen Stadt erhalten sowie Punkte sammeln und mehr über die globalen Probleme erfahren, die zur globalen Erwärmung beitragen. Mit ihrem benutzerfreundlichen Design würde die Anwendung als praktische Lösung für Benutzer dienen, die einen positiven Einfluss auf die Umwelt ausüben und tatsächlich einen Unterschied im Kampf gegen die globale Müllverschmutzung machen möchten. Die Veränderung beginnt bei jedem Einzelnen von uns. Die Masterarbeit untersucht außerdem, wie die tägliche Beschäftigung mit der Abfallverfolgung zur Schaffung positiver Gewohnheiten beitragen, Benutzer dazu ermutigen kann, umweltbewusste Entscheidungen zu treffen und den Benutzern schließlich das Erfolgsgefühl geben kann, dass sie helfen und zum Wohl des Planeten beitragen. Die Ergebnisse der Forschung zeigen, dass die Masterarbeit den Nutzen der Verwendung digitaler Tools im Kampf gegen globale Umweltprobleme hervorhebt und zu einer proaktiven täglichen Abfallreduzierung anregt, was beweist, dass die Anwendung eine Lösung für das Forschungsproblem bietet. Darüber hinaus bestätigt die Forschung, dass die Nutzer, sobald sie sich engagieren und das Gefühl haben, etwas beizutragen, die Gemeinschaft dazu bewegen, gemeinsam zur Abfallreduzierung beizutragen und eine sauberere Umwelt zu fördern. Was für zukünftige Verbesserungen noch zu tun bleibt, ist, den Markt zu erweitern, um andere österreichische Städte einzubeziehen, Partnerschaften mit lokalen Recycling-Initiativen einzugehen, um eine langfristige Abfallreduzierung zu fördern, und die Anwendung weltweit einzuführen.

## Acknowledgment

The digital revolution which is happening in the current time when we as individuals are blooming is bringing its own benefits, as well as downsides. Our mission as individuals is to try to use all the revolutionary digital tools which the technology is offering us in order to pursue positive behavior and influence changes in our communities. As such, WastelessWizard.IO has a goal to contribute as a solution which is small but can bring amazingly great results in the fight against over-consumption and low awareness in regards to actions which lead to problems with waste, while turning our households into heavenly sustainable places with zero-waste. Change is integrated in each of us and it starts with small steps taken daily for the greater good of the community. The work performed during this research and development of such a product can hopefully serve as a source of inspiration for future researches, development and enlargement of using gaming practices into solving complex global problems.

I would like to express my sincerest gratitude towards my supervisor Univ.-Prof. Dipl.-Ing. Dr. Helmut Hlavacs, for constantly pushing me to think outside of the box, continuous searching for complex problems which need solutions, for their continuous support, guidance and expertise shared throughout this research. The insightful feedback and encouragement have been fundamental to the completion of this thesis which brings me a feeling of proud accomplishment in the fight for a greater good. It is never a one person job and thankfulness goes to every individual included in the thesis from friends and colleagues sharing opinion, to participants and testers for giving valuable feedback.

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# Contents

<b>1</b>	<b>Introduction</b>	<b>6</b>
<b>2</b>	<b>Related Work</b>	<b>9</b>
<b>3</b>	<b>Used Techniques in WastelessWizard.IO</b>	<b>10</b>
3.1	Game Based Learning and Gamification Theory . . . . .	11
3.2	Self-determination Theory . . . . .	12
3.3	Habit Formation . . . . .	14
3.4	Nudging Theory . . . . .	15
<b>4</b>	<b>WastelessWizard.IO as Solution to the Problem</b>	<b>16</b>
4.1	Research Questionnaire . . . . .	17
4.2	User Use-Case Scenarios . . . . .	26
4.3	Application Features . . . . .	35
<b>5</b>	<b>Application Development and Architecture</b>	<b>48</b>
5.1	Technology Stack . . . . .	50
5.2	Software Architecture . . . . .	57
<b>6</b>	<b>Evaluation</b>	<b>61</b>
6.1	Evaluation Results . . . . .	63
6.2	Discussion . . . . .	66
<b>7</b>	<b>Future Work and Conclusion</b>	<b>67</b>

# 1 Introduction

Modern life, modern technology and modern advanced solutions are continuously introducing innovative methods which aim to target the generating of greater good for the population. Newly tailored developments aim to bring easiness into the life of the busy and fast paced life of the individuals. As the resources and research pools are growing on a daily level, researchers have found scientific advancements which can serve as possible ways to re-purpose plastic into remarkable products like electricity or running shoes and recycle every possible category of waste which can then be reused as materials for development of pavements. Even though there have been significant improvements on the topics of pollution, elimination of single-use plastic items and waste management, there is still a global challenge with over consumption of waste which persists both in developed and undeveloped countries across the globe. Despite several breakthroughs found in waste management and recycling, the society often takes steps backwards with waste accumulating at an alarming rate. Human society in the past decades is facing a sharp increase in the growth of the population and therefore urbanization, which makes the process of waste management as such a process which requires strategic technological development and proper modeling of urban reduction processes. [38] The rapid growth of the population is further on influencing the mass production and excessive consumption of single use items which are derived from cheap fossil fuels, crude oil and natural gas. Both the mass production and excessive consumption are influencing the growth of unnecessary waste which is leading to severe environmental consequences. These consequences are impacting the overall ecosystem, as they contribute to extinction of certain species in the flora and fauna part. Extinction as a process has always been part of the evolutionary cycle but during the most recent decades, the rates of extinction for certain species are from ten to a hundred times higher than during pre-human era. [30] Another disadvantage is coming from the paper industry where massive deforestation has been made for the production of paper which contains ink, dye and additional toxic materials which can be carcinogenic when buried or mixed with groundwater through the traditional waste burial methods. [40] Its the twenty-first century, the most revolutionary century so far in human mankind, where technology is growing faster than the speed of light, there are modern production techniques, yet still mass consumption of waste is one of the biggest global problems in the world. The mass consumption of waste is yet another factor which is contributing to global warming, to air pollution, to oceans filled with plastic and to tons of waste which has no place to be stored. We live in a capitalistic world where the vendors want to make the biggest profits recorded, corporations use cheaper materials just to ship the product as soon as possible on the counters while they do not care about the consequences of the mass production of seasonal trends. All the waste produced, if not recycled or not reused, in most of the cases does not end in the garbage disposal landfills. It is either transported to a third world ranked country or it is left to be decomposed in forests, oceans, rivers and mountains. The waste does not simply vanish. The nature and all its processes are like a

linked chain. If one of the chains in the circle is broken, then the circle will not be fully rounded. Once the waste is not managed as it should be, it becomes dangerous to the other living organisms on the planet.

For example, in the case of pollution caused by plastic bottles, the research shows that there are ten rivers which are the biggest contributors to the ocean pollution. These ten rivers carry up to 90 percent of the overall world plastic waste. These ten rivers, which are shown in Figure 1 below, carry up to 90 percent of the overall world plastic waste. Year by year, the problem with the plastic waste continues to grow as the biggest producers and companies like Coca Cola, Pepsico and Nestle are not managing their plastic waste effectively [15].



Figure 1: Biggest ten river polluters in the world [61]

Overconsumption as a term is often being used in discussions where there is critically high level of consumption of certain things which has become a normal level accepted within the society. As such it can be used in various fields like medicine, waste, fashion marketing and many more. Lowering down or even trying to control the rising consumption of waste has become one of the most impacting challenges in the twenty-first century. [63] Waste has been piling up even more than in the past and the primary reason for that is the annual increases in the consumption of clothing, food and electronics which further on contributes to higher usage of energy, labor force and raise of carbon emission gas. Such processes are only contributing to total collapse of the eco-system and to development of holes in the environment, which would be too hard and costly to fill. Waste generation is increasing fast as a pure consequence of all the activities of the human population. [38] All the mentioned processes function in a chain where it is crucial to recognize that the behavior of the consumers and the greedy attitude of the producers are the driving force for

the major problem of waste over consumption which the society is facing. That greediness and toxic behavior are further distributed in the whole ecosystem, as everyone included in it from the planet to the species to the individuals could feel the pressure applied from the harsh reality which is stating an urgent need of change.

The need for change is further pressuring the emergence of creative and sustainable solutions. In order to try to battle the consequences and not get to a stage where the damage done will be irreversible, it is important to understand how to target the compelling consumers as the drivers of the waste over-consumption problem and derive a solid understanding of their mindset. There are already many initiatives taking place which focus on the implementation of necessary measures to save the environmental system by focusing on tactics to reduce waste and to enlarge the recycling efforts. All of the initiatives contribute positively but often fall short because they lack the needed long lasting impact. This brings us to the understanding that not only drastic measures through the implementation of technological advancements are needed but primarily a shift in human behavior should be performed. Raising awareness among the population and the nurturing of responsible and healthy habits are the first key steps in order to tackle the issue of waste over-consumption. Once the individuals recognize their individual impact towards the issue, they would start to make contributions towards a cleaner environment as the culture of sustainable habits would be part of their everyday life. It is essential to understand the motivators, the behavioral triggers, the practices and the obstacles the individuals have in order to design a well-functioning waste management system and to lower the amount of waste consumption.

One innovative approach in order to foster sustainable habits and to track the input of waste in the households would be the development of mobile application with the use of psychological techniques and game-like elements in order to engage and motivate individuals to behave in a greener way. [56] Such green applications can contribute for individuals to raise their awareness, apply sustainable practices and educate on eco-friendly practices. [57] [53] That is why this Master Thesis is conducting a research on the impact of such green mobile application and offering a tailored developed solution which is integrating progress tracking, waste calculation, habit formation through knowledge sharing, sustainable practices and gamification techniques through points scoring and leaderboard elements, aiming to transform recycling and waste consumption tracking into an interactive and rewarding experience. The product from this research paper is a cross-platform mobile application called '**WastelessWizard.IO**' which has the potential to significantly increase participation of the individuals and which is committed to reduce waste. By making recycling and sustainability engaging and very accessible with only several clicks, 'WastelessWizard.IO' as a product can help bridge the gap between awareness and action, as it brings the individuals on a personalized path towards the contribution to a more environmentally responsible society and towards greener households, free of not needed waste.

## 2 Related Work

Whenever the waste is not managed properly, it can also be burnt out in the open. That is why it is particularly important to understand the deep link between waste and climate changes. There are several factors which contribute towards global emissions of greenhouse gas and even though waste management is considered as a small one, it is one of the most important ones. Making less that goes to waste saves the businesses significant amount of money by actually lowering the energy and labor costs while also using less raw material. [64] The rapid growth of the population of the world, as well as the capitalistic way of living, brings with itself the production and the growth of solid waste. What is considered as solid waste? Solid waste is considered to be usually non-hazardous commercial waste like food, paper, plastic, textile, glass or metal waste. [62] Massive productions, air and water pollution, as well as single-use items are all part of the equation which contribute towards build up of waste. One additional contributor to the build of waste is also food which gets bad, it is not eaten or not even sold before its expiration date. [44] In the developed countries in the world, it is analyzed that the consumers are actually the most responsible factor for the largest share of waste along in the chain. This implies that not only 53 percent of total food produced is wasted in the European Union but also other very important resources like soil, water or energy are used up. These important factors contribute to huge amounts of unnecessary CO<sub>2</sub>, affecting further on to problems related to climate change.[2]

Waste production has historically been a problem which has been caused by humans. It is calculated that the global waste production is 0.74 kilograms per person on a daily basis. On a country basis these rates are varying significantly from country to country and they range from 0.11 kilograms to 4.54 kilograms per person on a daily basis. [33] In order to battle the problem of waste management, in the past decade a visionary concept called **zero-waste management** came to light which focuses on total reduction of waste through mindful consumption and sustainable production. [62] In the context of waste management, a certain strategy needs to be taken in order to minimize the ecological effects of all the processes included in the management. This means that the zero-waste management policy is targeting a decrease in the use of energy, minimizing usage of water when it is not needed, decrease of the carbon footprint on the environment, reduction of fast-fashion, correct treatment of waste and most importantly a total shift in the behavior, mindset and attitude of the society. [5] A very important factor in the sustainable production is that the production of the products should be from eco-friendly materials, with the use of natural resources as well as instructions for proper recycling. [67]

The question now would be to ask what could actually be done to tackle this very concerning problem with waste consumption. Most individuals think governments should be the ones to take action and put hope in them to form stricter laws and impose very high fines. There are already such laws imposed across several countries in the world and European Union as well. One example that was already put in practice is that the EU commission

has requested manufacturers in 2009 to agree on a unified connector for cell phone chargers. [26] There have been other practices in other countries as well like Singapore which take zero-waste management seriously. Singaporean government has created the Singapore Green Plan which as a main objective has a plan to increase the recycling rate for all types of waste up to 70 percent by 2030 while in parallel reducing the need for further waste facilities. [25] There are many obstacles, challenges and barriers on the way to zero-waste lifestyle. These obstacles range from direct monetary expenses for the governments as well as costs which would include the time and the human resources needed in order to first implement the new environmental enhancements. [47] Next thing would be that every material included in the production process or the consumption in the society should be from recycled nature. [54] The government could try to also impose stricter fines in order to minimize waste but that brings another sort of a challenge as fines would be nearly impossible to be created for waste stored in a public place. Final thing would be to continuously foster learning, development and effective communication in the society. [43]

However, all challenges and barriers put aside, it all comes down to one thing and that is awareness. Whenever individuals do not have awareness on a certain topic, they do not understand the core of the problem and as such, they are not able to prevent the problem from happening. It even happens that due to not being aware enough, the individuals as such are the sole creator of the problem. Governments should help to tailor and promote zero-waste management journeys which would support the formation of new habits. [21] That is why the main objective of solving the waste problem and stepping forward to a zero-waste society requires a lot of work, education and knowledge. When the knowledge is accumulated, it can be put into praxis and with the work done on a daily basis the problem would get smaller.

### **3 Used Techniques in WastelessWizard.IO**

As the name of this research paper indicates, a certain mobile application called by the name of WastelessWizard.IO is implemented in order to combat recycling and to target zero-waste households. The application is evaluated and explained in details in the next sections to come. However, in the following section there would be a detailed coverage of all techniques which are used and implemented inside the application. The primary focus of the WastelessWizard.IO as an application would be to contribute to solving the global issue regarding consumption of too much waste in each household. In order to make an impact, the application would need to be designed as an interactive cross-platform application which would include several human-computer interaction techniques like Gamification and Game-Based Learning, plus quite a few of well known and researched psychological and motivational strategies like Nudging Theory, Self-Determination Theory and Habit Formation. The purpose of using the previously mentioned techniques and strategies would be to provide a broader engagement of the targeted users. There is already research

conducted that persuasive mobile applications can make a big influence on changing existing behavior and formation of new habits. [32] With the inclusion of the already mentioned strategies, the users would raise their awareness and educate themselves to consume less waste even when they are doing their weekly regular supermarket shopping.

### 3.1 Game Based Learning and Gamification Theory

When creating an application which has an intention to be very interactive and engaging with the user, the first two related methods in order to make the user engaged would be to implement Game-Based Learning and the Gamification Theory. **Game-Based Learning (GBL)** originated far back in time in the early 1950s and thirty years later, scholars started to research the correlation between games and learning. [42] Game-Based Learning is referring to a learning method where by applying games or related concepts and designs, the learners get immersive learning experience while mastering a certain skill. [42] This way of learning is usually associated with classroom setting with components where leaning is realized through game. [19] Even though WastelessWizard.IO is not intended to be a learning application at first place, the concept of Game-Based Learning can also be used in the application as the users would still learn and build new habits towards mindful waste consumption.

In addition to Game-Based Learning, there is one additional technique which is frequently implemented when designing applications which have the purpose to target certain habit or behavior change. This technique is known as **Gamification**. Gamification is defined as the integration of game elements into real-world context for applications which are not related to gaming. The primary objective of Gamification is to enhance human motivation and to optimize the performance of the individual in relation to a specific activity. It has the capacity to improve the motivation of the individual. [50] [41] One of the many reasons why both Game-Based Learning and Gamification have become really popular and useful is because gaming is considered as motivation and motivation is the driving 'why' of the behavior of individuals. Every step taken and every habit built is based on how much motivation lies in each of us. [34] Gamification has been recognized as a strategically effective approach for implementation of sustainable behaviors and encouraging long-term engagement among citizens in various societal contexts, which is the whole concept behind the WastelessWizard.IO application. Social mobile games and applications have a huge potential to build additional motivation and to promote concrete activities to be taken towards mindful recycling and waste consumption. [29] [56]

There are several elements which can promote the game design inside an application like points, feedback, leaderboards, performance or badges. [50] Some of these concepts and elements which are part of the game surface were utilized during the development of the WastelessWizard.IO application and they are the following:

- **Points** - After successful input in the daily waste calculator, the users would gain points. By consuming less waste, the users would gain more points which would make

them more involved and make them use the application on a daily basis.

- **Score leaderboard** - Based on the points received, each user would be able to see how much waste he consumed and on which place in the leaderboard the user is. That way the user can track the progress made.

With the implementation of the correct strategies and concepts from Game-Based Learning and Gamification, it is expected that the users would additionally have a sense of belonging. A belonging to the community which they need to take care of by. As part of the integration of this technique with the 'WastelessWizard.IO' application, there is a special screen which can be reached when the user navigates from the 'User' screen to the 'My Waste Rankings' screen. Shown in Figures 2 and 3, two scenarios can be seen where a user is saving waste, has a high place on the chart and receives an inspirational personalized message, as well as a user which could make more effort in the process of saving of waste.

### 3.2 Self-determination Theory

Another very important theory which is implemented in the WastelessWizard.IO application is the **Self-Determination Theory (STD)**. The Self-Determination Theory suggests that individuals need to feel or be motivated in order to grow and perform change by simply following three important and combined psychological needs. The theory as such is proposed from the American scientists Deci and Ryan.[17] [65] This theory suggests that individuals are indeed able to become self-determined when their needs for competence, connection and autonomy are fulfilled. The three concepts for autonomy, competence and relatedness are the driving force of this theory. The concept of autonomy explains the feeling that one has a choice and that choice is endorsing one's behavior, whereas the concept of competence relates to the experience of mastery and being effective in the activity which is performed. The final concept, the concept of relatedness reviews the need to feel connected with others and a belonging feeling to the community. [35] [17] Having in mind the context behind the 'WastelessWizard.IO' application, all these psychological principles are deeply embedded inside it in order to encourage the users to be actively engaged in the waste reduction process by making them feel competent in the contribution they are putting, the autonomy of their choices and connection with like-minded members of the community. With the fostering of intrinsic motivation, the application would not only enhance user participation but will promote behavioral changes which would be long-term.

The final aim of these three concepts is to create motivation in each individual. Additionally, the Self-Determination Theory is founded upon two fundamental assumptions [35]:

- The need for growth is the driving force of behavior. People are actively directed

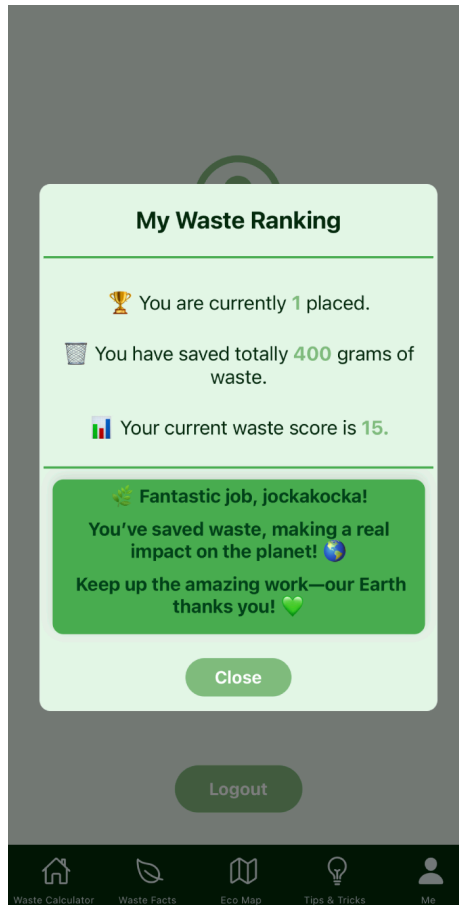


Figure 2: Positive Ranking

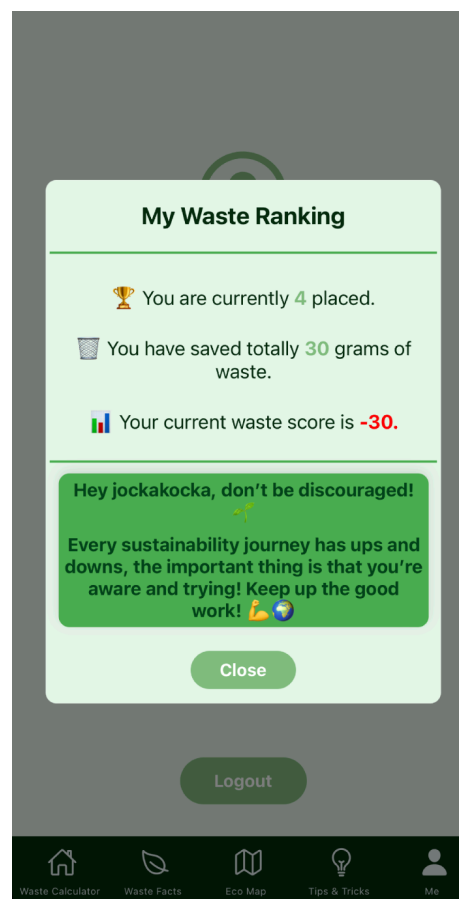


Figure 3: Negative Ranking

towards growth, meaning that gaining a certain level of experience and mastery over the challenges are essential for developing a cohesive sense of self.

- Individuals are often motivated by external rewards, whereas the important motivation is the autonomous motivation. This means that the focus is on the internal sources of motivation such as a the need to gain knowledge or to gain independence.

In order for this theory to be put into practice, it is important that WastelessWizard.IO focuses on providing meaningful positive feedback to the users in order for them to understand their impact. Once the users get educated in the application through the usage of 'Tips and Tricks' feature, they will consume less waste, thus the concept of autonomy will be achieved. Once they continuously use the 'Product List' or 'Store Map' feature in the

application, they will become more effective in the consumption and management of waste and the concept of competence will be achieved. Once the users understand that what they give will serve as impact for other users in the community and receive positive feedback by tracing their points from the 'Waste Calculator' feature, the concept of relatedness will be achieved.

### 3.3 Habit Formation

It is scientifically proven that each human needs at least twenty-one days of repeating the same action in order for the action to develop as a habit. Habits are cognitively encoded as associative links between specific goals and corresponding actions.[1] With regular repetition of the same process, a certain behavior can become automatic or habitual. That same repetition is part of the process which is called **Habit Formation**.The small changes approach where you do small but significant changes on a daily basis when paired with Habit-Formation practices, has proven to be a positive strategy when targeting behavior change.[24] Habit Formation is structured around three fundamental and essential components:

- The context cue which can be a prior action, a certain location or any activity which can trigger the start of the habit, meaning anything which can associate the individual to the habit.
- The behavioral repetition is the repetition of the behavior which is the actual habit the individual has.
- The reward which is the positive feeling the individual feels after, during practicing or completion of the habit.

All these three components are perpetuated within a cyclical process known as the habit loop, which progresses sequentially through four stages from cue, towards craving, later on response and ultimately reward. [11] The process of Habit Formation is commonly structured around the three R's, which serve as its foundational principles:

- **Reminder (Cue)** – This functions as a trigger that initiates the habitual behavior or the cue that starts the traffic. For example for the WastelessWizard.IO application, the cue would be too frequent throwing out of the trash bin.
- **Routine (Behavior)** – This is represented by the repeated action performed in response to the cue or in short the habit itself. An example like this which can be realized in the WastelessWizard.IO application would be that the user will use the calculator for the waste consumed after every supermarket visit.
- **Reward (Reinforcement)** – The benefit or the reward reinforces the behavior by providing a sense of satisfaction, thereby strengthening the habit over time. In

the WastelessWizard.IO application this can be realized by lowering down the daily consumed waste by following the tips and tricks provided in the application. When the amount of waste consumed decreases over time, the user will receive rewards and a dose of satisfaction, as his behavior brought impact for the greater good of the community.

If the reward is positive, then the user will have the desire to repeat the action the next time a reminder pops up and in that way the habit will be formed.[7]

### 3.4 Nudging Theory

In order to stay consistent to a certain habit, some individuals need a certain daily push. That is when **Nudging Theory** is being applied. Nudging Theory is a theory and a behavioral science concept which is first proposed in the book 'Nudge: Improving Decisions About Health, Wealth, and Happiness written' by Richard Thaler and Cass Sunstein. [58] This theory is based on the idea that subtle and small interventions which are called nudges can be an influence on the behavior and choices done by individuals. It is grounded on the principle that by structuring the decision-making environment, the choices made by individuals can be subtly influenced and would thereby increase the probability of a selection of a particular option over other options. [58] With the use of this theory, both positive reinforcement as well as indirect suggestions are proposed, which are a way how to influence the behavior and decision-making process of individuals. The small reminders and the implementation of the small changes could make a greater benefit in the solution of the problem.

For Nudging Theory to be effectively implemented and bring results, it is essential to incorporate strategically designed nudges within the application itself. These intelligent nudges should be designed to function as subtle facilitators or guides, influencing user behavior without eliciting a sense of intrusion or negative feeling. [31] Nudges are already implemented in many mobile applications and they can be recognized easily. For example, a nudge is a simple notification on your Duolingo application saying that you will lose your daily streak if you do not perform your daily learning. Duolingo simply applied loss aversion by sending a reminder. [10] If the implemented nudges are correctly used, nudges would guide individuals towards a predetermined and optimized course of action, aligning with their contextual state within the application while fostering positive behavioral outcomes.

When implementing nudges as part of your application, there are certain aspects which need to be taken into account for the effectiveness of the nudges. These aspects involve the determination of the appropriate timing for delivering nudges, identification of which user specific segments to target, implementation of the most effective nudging techniques and offering guidance exclusively in situations where it is needed. Based on the conducted research and the correct nudging techniques available, these are the most effective nudging concepts which should be used in the WastelessWizard.IO application:

- **Daily facts** – These daily facts and reminders could remind the users of the influence which waste has on certain processes in the eco-system all around the world.
- **Personalized messages** – At the end of the daily waste calculation process, the user would receive messages which are personalized depending on the waste saved or generated.
- **Recommendations** – Through the various tips and tricks which are provided in the application, the users can opt for healthier and more ecological choices.

## 4 WastelessWizard.IO as Solution to the Problem

Over consumption of waste is a largely growing environmental issue which is primarily driven by unsustainable manufacturing practices and living in an era of consumerism. Most households and individuals are generating large amounts of waste on a daily basis due to lack of awareness about more sustainable products, over-purchasing of products and wrongful packaging of products. All of the excess waste which is produced has effect on other processes and contributes to ocean pollution, increased emissions and landfills, as well as households filled with things of no need. The over-production is further more contributing to a large amount of food waste which is a significant concern, as billions of tons of food are ending up in the landfills even though there are still countries around the globe which are facing hunger issues in their population. Those same hunger issues are contributing to emergence of diseases and a shorter life century of the individuals living in those countries. This pattern of the over-consumption by the consumer which is fueled by the internal desire and chase for material goods, as well as constant monetary growth of the producers is the navigator towards a total environmental collapse. [63]

In order for the problem of over-consumption to be lowered down to a smaller problem either the producers would stop to produce too much quantity or the consumers would become more aware of their practices and their consumption. The first part of the equation is part of a quite unreal scenario while the second part of the equation is something which could be worked on, even though it would be a tough battle to get the consumer out of the over-consumption zone. That is where applications and software like WastelessWizard.IO could come to the rescue. WastelessWizard.IO as such would be a small solution which can be implemented to lower down the problem the community is facing with over-consumption of waste. So, how would this small but meaningful solution be technically designed, practically used and usefully addicting? The application is designed to be a cross-platform application which means that the application would be available on every mobile phone. In our current world population, mobile phones have become a necessity and they are a widely used communication tool, especially in developed countries like Austria which is the pilot target country for roll out of the mobile application. As such, WastelessWizard.IO is designed as a cross-platform mobile application which will be easily accessible for people,

just several clicks away from them. After the technical details were established, the next steps would be to make the application to be practical and to be of usefulness to its users. The first practical thing inside the mobile application is that it is designed to help its users to calculate the waste which is entered in their households on a daily basis. The waste calculation can play a significant role in battling the over-consumption problem by tracking the amount of waste generated and trying to implement practices to lower it down. Like this users could view their consumption practices and identify possible areas for change in order to become more sustainable, while gaining points and fighting for a top space on the user's leaderboard list.

The application goes way beyond waste tracking, as that is only one of the many practical features it offers. WastelessWizard.IO is additionally offering tips and tricks which are based on several categories from food waste, to fast-fashion and to toxic material recognition. All these small but useful recommendations can include practical advices which can be incorporated in the daily life of the user. To further make the application more practical and useful, WastelessWizard.IO includes a directory of eco-friendly products and eco-stores which are selling eco-friendly products manufactured in normal and natural conditions, without toxic materials. The users of the application can explore stores which offer refill products, products from BIO background and fresh products coming straight from the farm. Apart from the stores, the users can also gain knowledge on sustainable products which are either with biodegradable packaging, not harmful to the individuals health or without any packaging. The list of eco-friendly stores and products would make it easier for the user to access and use the provided sustainable alternatives, which means that the application is encouraging zero-friendly lifestyle and more sustainable purchasing. The final useful thing which the application promotes is the waste facts section which has an intention to educate the user of certain problems over-consumption contributes to and raise awareness.

With the thoughtful combination of all the useful and practical implementations for waste tracking, sustainable shopping options through stores and products, awareness raising through waste facts and small advices in the format of tips and tricks, WastelessWizard.IO as a cross-platform application is already having a potential to rise into a powerful product which can further more leave a long lasting positive change, raise awareness in the community and lower down the problem of over-consumption by turning households into zero-waste ones.

#### **4.1 Research Questionnaire**

In order to maintain strong foundations for the research of the following Master Thesis, a certain research question should be asked for which the research would be created. As every other research, a research paper and a Master Thesis Study would not be complete without a definition of a solid research hypothesis or a research question which is the root of all research conducted. The research question which the following Master Thesis should

give an answer to is whether an user-friendly and interactive mobile application developed with the use of gamification methods could contribute to solving a global problem like over consumption of waste. Once the research question has been formulated, the next phase before the start of the development of the waste management application would be to conduct a questionnaire for the research topic. Conducting such a questionnaire is critical in order to ensure that the solution presented with the application would align to the needs, behaviors and the expectation of its target audience. A research questionnaire would help in the process of gathering essential data regarding the user practices with recycling, the consumption habits and the awareness level. All the data gathered from the answers of the survey, would help to identify the spaces where improvement could happen, as well as navigation towards what the targeted users would appreciate to see in the application. The survey could also help identify whether the audience actually has a need for such an application and whether such an application would bring easiness and effectiveness in the daily life. Ultimately, a well-structured questionnaire acts as a road map for creating a solution that not only meets technical objectives but also fosters meaningful behavioral change in waste management. All the research conducted before the actual development is maximizing the productivity and enables more focus on essential features by prioritizing user satisfaction while avoiding unnecessary complexities.

- **Question Evaluation:** After the research question and the target audience have been identified, the next step would be to prepare the questions inside the questionnaire. The goal of the questionnaire is to provide meaningful data for the development phase of the mobile application but also to have questions which are not too complicated, have concise point and the answers are straightforward. [49] Whether the questionnaire is effective depends on the clarity and the structure of the questions, which determine the quality of the responses received from the participants. Well-crafted questions should be in alignment with the goals and the objective of the research for this Master Thesis. The easiness of the questions would also make the user more engaged when answering. By evaluation of each question, the development process further on can continue with clear understanding of the habits, challenges, expectations and consciousness of the target audience.

For the purpose of the Master Thesis research, the research questionnaire was sent out to people living in the city of Vienna. In order to gain more insight, eighty-five people gave their insight by answering the questions related to the topic of Zero-Waste Households. The research questionnaire consists of twenty-six different questions. The length of the questionnaire is relatively short in order to keep the attention to the participant. The questionnaire contains different types of questions which can give variety of answers. The type of questions are several **demographic** questions, **yes-no** questions, **multiple choices** possible questions, **open answer** questions where the participants in the questionnaire could give their opinion, **check-box** questions, as well as **linear scale** questions where the participants could give a rating for certain

topics. The questions in the questionnaire were tailored in a way where they would provide a meaningful insight inside the participants thinking and would help tailor a better user-friendly application.

- **Research Results:** As expected during the design period of the questionnaire, the answers provided by the participants answering the questionnaire brought a significant insight in the recycling practices, waste thinking as well as ideas which would make the WastelessWizard.IO application a more useful application for its users.

The first set of questions in the questionnaire were focused to understand the demographic background of the users, like gender, age group, district of living in Vienna and number of people living in one household. What was interesting to see was that the participants vary from different age groups and that they live in different districts across Vienna. The differentiability shown in the answers to these questions, which can be seen in Figures 4, 5 and 6 listed below, shows that mixed participants were included in the questionnaire, which indeed would help understand the thinking of every age group and would enlarge the target audience of the application to be anyone which lives in Vienna and is above eighteen years old. In Figure 4, the results show that there are participants from every age group, while the majority of the participants with 34.1 percent are in the age group from twenty-three until twenty-seven years. In Figure 5, the answers are very mixed and once again there is a participant living in each of the twenty-three districts in Vienna, while the majority of the participants with 14.1 percent live in the eight district - Josefstadt 1080 and 10.6 percent of the participants live in the second district - Leopoldstadt 1020. In Figure 6, the results show quite a big gap where 48.2 percent of the participants answered that they live in a household which is consisting of two people. These three questions and the answers gathered form the foundation of the further questions.

The second set of questions is aiming to understand the recycling practices of the participants. This set of questions would help to first comprehend whether the participants actually recycle, then to form a clearer picture of the recycling practices of the participants and figure out which categories are used in the process of the recycling and selection of waste. A really positive note for the future of this research and the development of the application is that sixty-seven participants out of eighty-five chose that they are recycling. Seventy-three out of the eighty-five participants selected that they divide waste, which is 85.9 percent from the participants as it can be visible in Figure 7.

Additionally, it is interesting to see that the participants do not only separate waste in the categories listed but they also separate waste in additional categories which they wrote. Those categories are cooking oil, batteries and electronic parts. From the options listed, most of the participants separate waste based on glass, paper, Restmüll

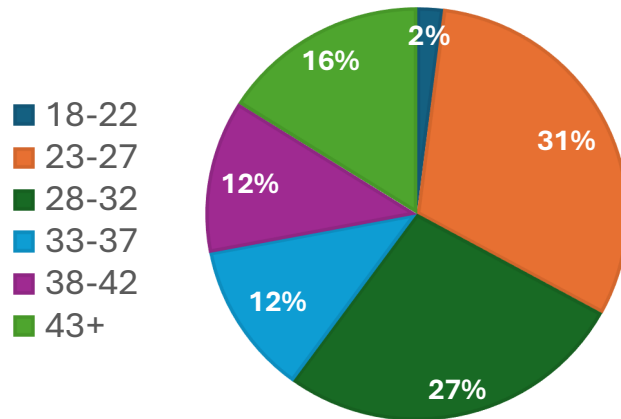


Figure 4: Results from Research Questionnaire about the age group

(non-recyclable) and plastic waste, while less participants separate the waste based also on metal and organic origin, as it can be seen in Figure 8.

The next phase of questions focuses on getting more insight in the practices the participants use in order to eliminate single items and not needed waste in their households. Majority of the participants with 69.4 percent think that they produce too much waste on a daily basis in their households and the same percentage of participants have already tried to eliminate single-use items which shows already that the participants have already consciousness regarding waste and how to reduce its consumption. So what do the participants actually do in order to reduce waste? Majority of waste in the households comes from excessive shopping, whether it is in the supermarket, at the fashion store or on Amazon. More than half of the participants with 74.1 percent rate answered that they use reusable bags and with 52.9 percent rate answered they bring a backpack when shopping, even though the twenty-six participants still answered that they buy their bags from the store. This number is quite high as it is 30.6 percent of the whole participants. All the answers with the participants rate can be viewed in Figure 9.

Almost all of the participants own a reusable water bottle or thermos, while fifty-five out of eighty-five participants use reusable containers for their food. For the question what do the participants do in order to reduce the consumed wasted in their households, the participants answered mostly in the majority that they bring their own bag when shopping, they buy fresh foods instead of processed or packed ones, they buy only what they need and try not to over consume on fast-fashion. Every answer from the answers which were listed was clicked at least once as it can be seen in Figure 10 listed below.

Based on the first three sets of questions covered, the participants have revealed

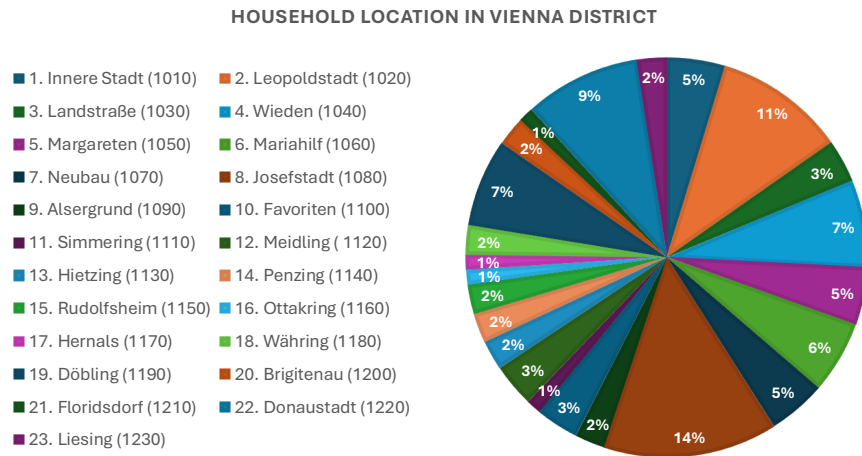


Figure 5: Results from Research Questionnaire about the district of living

their demographic data, their recycling and their waste elimination practices. These answers form a solid ground for the next two sets of questions which are left to be examined from the questionnaire. In the first of the two sets left, the idea is to get more insights in the personal belief of the participant, to understand the motivation and the psychological thinking in regards to zero-waste households. As a self rater, the participants were asked to share their honest rating for themselves on how they think they are doing it with recycling. Since Austria is a country which promotes a really high end culture for ecology, recycling and planet health, the results for this question came a little bit as a surprise. The rating scale is from one to five, where one is the lowest and it means the recycling is really bad and the participant could use some support, whereas five is the highest and it is meaning that the participant is doing really good. The expected result was that majority of the participants, which means at least 50 percent should rate themselves as four, even though that was not the case. As visible in Figure 11 which is listed below, only 38.8 percent or thirty-three participants have rated themselves with four, whereas 32.9 percent or twenty-eight participants rated themselves as three. Three is usually considered a middle rating which has more an incline towards the lower numbers in the rating scale. Majority of the participants with 83.5 percent or seventy-one participant answered that they would like their household to become a zero-waste household, which is exactly the answer that was expected here. The answers received for the last two questions only show that the research done in this Master Thesis will be beneficial and that users still need support in order to maintain a waste-free household.

It is in peoples deep nature that without the feeling of satisfaction, certain actions

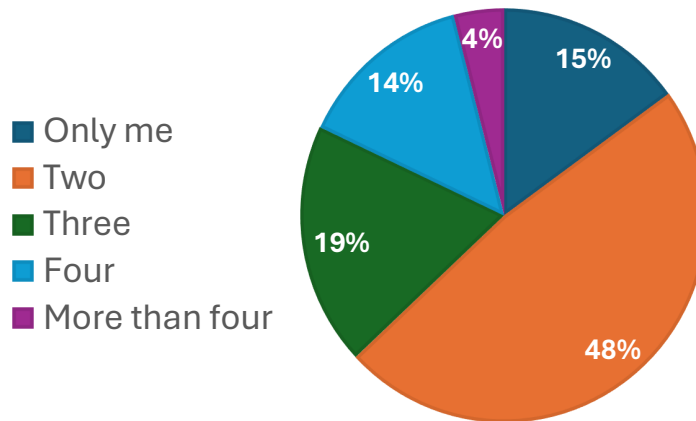


Figure 6: Results from Research Questionnaire about the amount of people living in the household

would not be happening. That is why the psychological aspect when building an interactive application is very important, as this would be a way to make the users addicted and interested in what your product is offering. There is a separate section in this Master Thesis which is called 'Used Techniques' where all the psychological techniques are examined and their practical use in the application is also described. That is why the last set of questions from the questionnaire is precisely targeting questions which would serve as guiders to understand the motivation of the users and what would actually be the driving force for them to use such an application. On the first question from this set on the topic whether the receiving of an award would motivate them to use recycle more, sixty-seven of the participants or 78.8 percent stated yes as an answer. This brings us to the next question whether the participants would use an application which would help them convert their household to a zero-waste one, majority of the participants fifty-seven or 67.1 percent voted for yes. Those fourteen participants who voted for no or maybe were asked to state what would motivate them to use the application. Some of the added answers were time, easiness to use, to be free of use and to make life less complicated. Some of the answers were taken out of the questionnaire and put into the following list:

- Easiness to use without too much effort.
- Knowledge sharing about eco-friendly possibilities.
- Application should be free.

The next question is related towards the desire of the participant, what would they want to see in the application and which features would bring them to use the

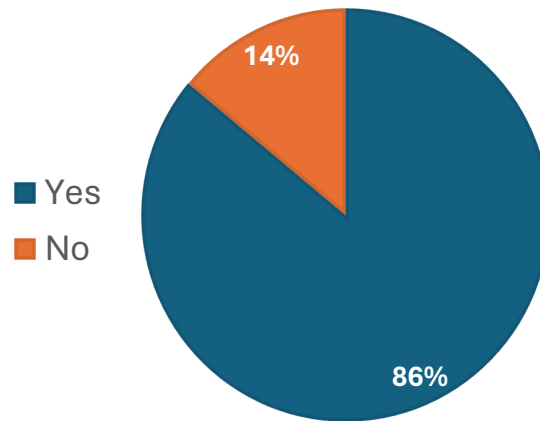


Figure 7: Results from Research Questionnaire about separation of waste

application on a daily basis. For this questions the participants clicked on every option which was provided as a possible answer, as it can be seen in Figure 12, while only five participants added other options as well like locations for recycling no matter the waste and especially locations for unusual packaging or very large items, rewards system and possible saving estimation.

Based on the answers the participants would mostly be interested in feature which would give a calculation of the waste consumed, calculation of the impact towards the planet, proposal of products and packages which are more eco-friendly, tips and tricks how to avoid waste and map with stores which offer products without packaging. The final question is an open answer question, where the participants were asked to state their opinion how the waste management can be improved in the community if an application for zero-waste management would exist. The answers which the participants provided here offer insight that there are several problems connected to sustainability and recycling and that at the end of the day it is important each individual recognizes its impact in solving the problems. The answers were grouped in several categories:

- **Easiness to use** – There were several answers which mention easy integration in daily life, user friendly application or easy tricks. The analysis here brings to a conclusion that people want their life to get easier and are looking for tools which would make their daily life easier. Life is already quite complicated and users do not need one more complicated thing to track. Conclusion is that it would be important that the application is easy to use, it offers an easy access into the features, it would provide easy access to recycling spots and eco-friendly stores and quick tips and tricks which can be incorporated in the daily life.

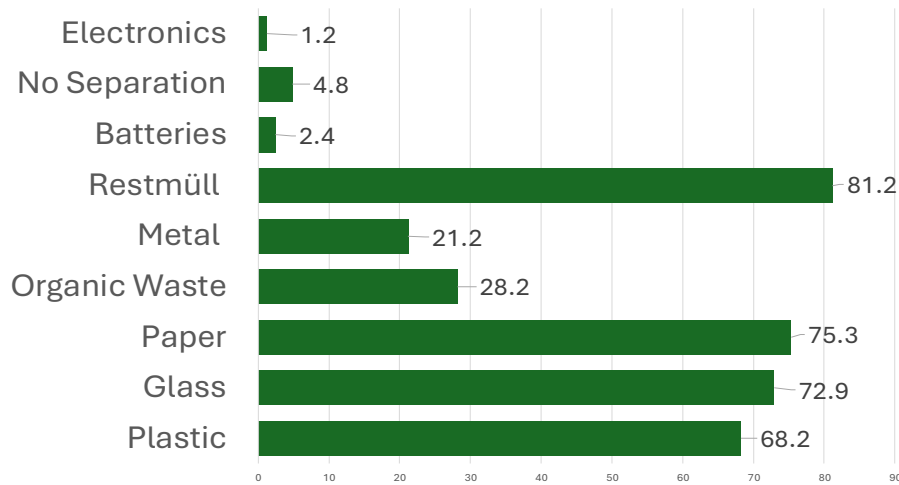


Figure 8: Results from Research Questionnaire about waste selection categories

- **Raising awareness** – In order for the users to understand their individual impact on this topic, those same users would need to become even more aware of the problem and get more educated on the root cause. Once the awareness is there, the users would need to follow the practices which would lead to better results. That would mean more awareness on biggest company polluters in the world, more education on healthy and eco-friendly materials, ways of less consumption and more education of the process of manufacturing. With constant reminders about the impact as well as the importance of their active participation. Knowledge is power and by educating more people, already part of the problem would be solved. Once you understand how much unnecessary things you consume, you will grasp why you produce so much waste in the household and you will start using practices to lower the mass down.
- **Connection with government services or similar platforms** – Collaboration with governmental services which promote the same vision as well as connection to similar platforms would make the application more exposed to the public, as it will be recommended by an official state service. Governments to also show visibly factories or institutions which produce too much or pollute too much. More knowledge to be transferred by panels organized from the local government in Vienna, good social media presence and exceptional marketing. Additionally, a solid connection to Magistrat - MA 40 for frequencies of pick up times recycled materials.
- **Identify target locations** – This would help the users to actually firstly locate stores which sell fresh products, products with better packaging, products from



Figure 9: Results from Research Questionnaire about the type of bags used during supermarket visits

natural production or products which come without any packaging. Secondly, it would help users to locate waste containers around the city. Most of the buildings have only non-recycled waste, paper and glass containers. Other containers like metal, plastic, electronic waste or clothing are located based on the district in several specific places across the district. For very large in size items, there are only several places around the city where they can be taken as waste. It would also be interesting to see where the waste is then taken and to offer tracking.

- **Rewards and challenges** – Include challenges in the application which would motivate the user to fight and make the challenges visible. People would like to show to the community that they make impact and it can be motivating for other users as well to join. The challenges would lead to rewards which could be redeemed in partner organizations.

All twenty-six questions and the responses given by the participants provide the necessary insights which align well with the main research objectives of this research paper, while confirming the key hypotheses. The participants responses were consistent and showed several target issues which can contribute to their behavior and awareness on the waste reduction topic. The collected data revealed clear directions for the design and development of the WastelessWizard.IO application. As a final result, the questionnaire successfully fulfilled its initial purpose and delivered the needed results which would be used in order to deliver the goal behind the WastelessWizard.IO application which is to reduce the consumption of waste in each households while raising bigger awareness on the world problem of recycling.



Figure 10: Results from Research Questionnaire about the practices used to reduce waste in the household

## 4.2 User Use-Case Scenarios

One of the first steps in the software development life cycle is to define the consumers and therefore create the needed use-case scenarios. As such, use-case scenarios are representing a fundamental aspect in the software development life cycle, as they have a goal to help in the definition of the different user groups from the target audience which would interact with any software product developed. This means that use-case scenarios could be of great help when building and developing an application such as the WastelessWizard.IO application. The idea behind the use-case scenarios is to map out the behavior of the users in the real world and to ensure that the needs which are derived from their behavior are matching and aligning with the design and functionality of the developed application. By ensuring that the design and functionality are aligned with the needs of the users, both usability and functionality should also be enhanced. Correctly modeled use-case scenarios can guide the development team towards prioritization of certain feature where first the features and functionalities with the biggest impact would be implemented. Functionality is not the only goal expected from use cases, as use-cases have an additional goal to foster long-term user engagement and to create change in behaviors by simply understanding how different types of users would interact and engage with the application.

Since the target group of users is already defined and the quantitative research survey has been conducted, as a next step before the start of the development phase would be to

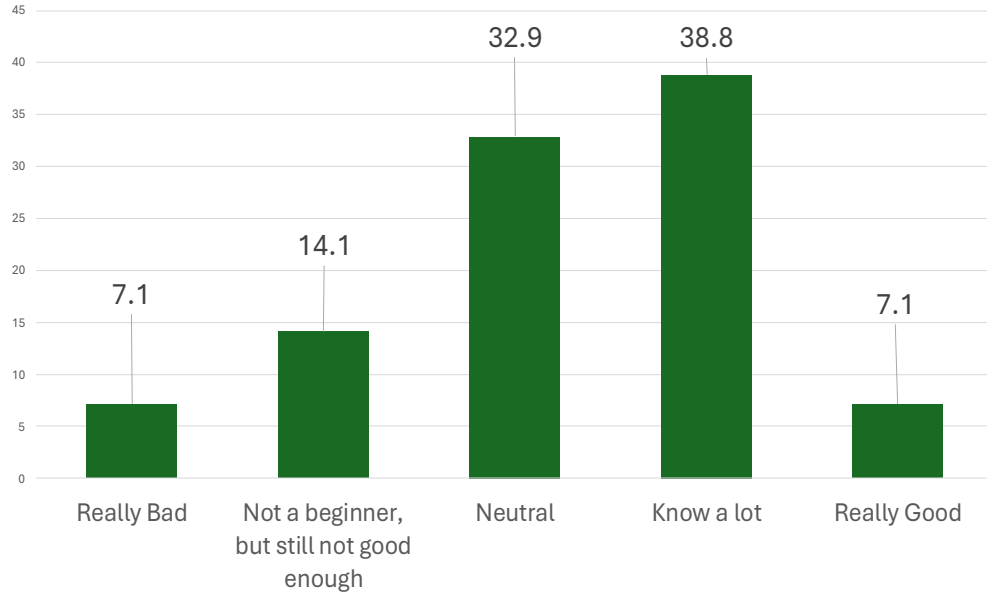


Figure 11: Results from Research Questionnaire about the practices used to reduce waste in the household

pick several different types of users and to deeply analyze their needs, behavior and way of living. By gathering a deeper understanding of the potential user or the consumer of the application, certain use-case scenarios should be modeled. Such use-case scenarios would perform a crucial role in the definition of the core functionalities of the application which would be based simply on following the needs of different sets of users. With the analysis of specific and different sets of consumers, the application can target specific pain points, motivations, intuitive design, differentiation from competition, interactive experiences and user centricity. For the purpose of the WastelessWizard.IO mobile application, it was decided that four different types of use-case scenarios would be modeled where each use-case would have a different type of user group based on demographic, social, marital and professional background. The use-case scenarios which would be further analyzed are regarding a young couple which recently started living together, a busy executive professional, a student living in a dormitory on a budget and a married couple with a small baby below one year of age. All the use-cases would be elaborated thoroughly one by one as follows.

- Use-Case 1 – Eco-Conscious Young Couple:** Marija and Stefan are a young couple which recently moved in a spacious apartment. They began their joint life together after five years of dating. Marija is a twenty-six year old pharmacist, while Stefan is a twenty-seven year old software engineer. Both of them have already a high level of consciousness about ecological and sustainability topics and regularly



Figure 12: Results from Research Questionnaire about features in the application

practice waste selection but saw they consume too much single-use items and plastic. However, they have trouble to find products which are more durable, do not contain plastic packaging and can not comprehend why they consume so much waste on a daily basis. They have time and their budget is relatively high for people of their age. Since they live in an apartment, they have space to store items. The use-case scenario is designed on the following use-case diagram which can be seen in Figure 13.

- **Preconditions needed:** The couple downloaded the application from the application market. Both Marija and Stefan agree that they will setup a joint profile in the application where they would be able to track their joint household waste and try to eliminate the consumption of single-use and plastic items. They are looking for easy ways where they receive actionable tips on creation and maintenance of a zero-waste household.
- **Steps Marija and Stefan take in the WastelessWizard.IO application:**
  1. **Household Waste Audit:** They use the waste calculator in order to understand from which products they consume the most waste. Since Stefan is a Software Engineer, he prefers to have the option for the products to be split by categories where the couple could only click on the product and also to have the possibility to see a broader list of items. The application

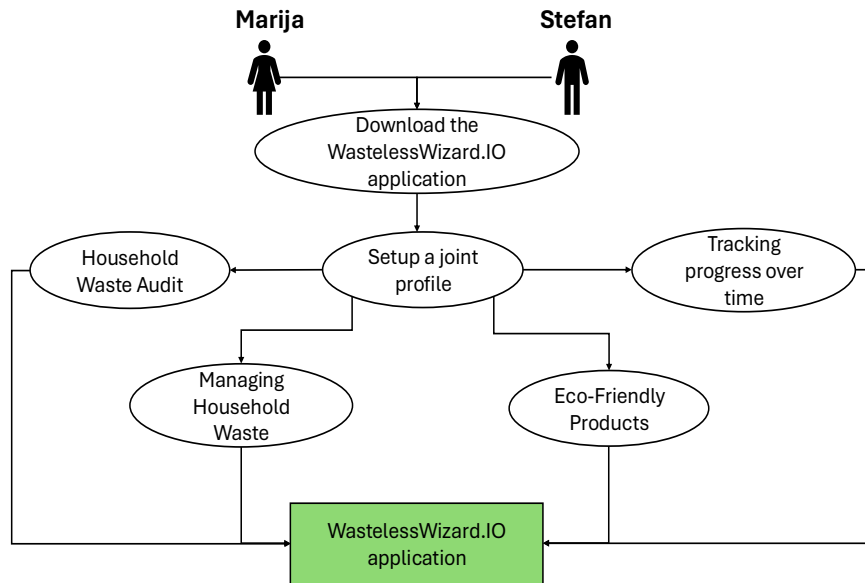


Figure 13: Use-Case Scenario for Eco-Conscious Young Couple

should provide insights on their environmental impact in terms of plastic grams saved and suggests alternatives.

2. **Managing Household Waste:** By giving out tailored tips and tricks, as well as waste facts, Marija and Stefan would learn certain practices how to lower down the household waste. For example, they would learn to repurpose the usage of items, to go to the fresh market or to design a smart shopping list.
  3. **Tracking Progress Over Time:** In order for their mission target to be achieved, Marija and Stefan need to track their progress. Therefore, they would be interested to see how much waste they have actually saved and what can be done with the waste which they stored. For example, it is interesting to note that around eleven plastic bottles are needed in order to develop pair of shoes. Showing this information to them would be beneficial in order to keep them motivated.
  4. **Eco-friendly Products:** To reduce the waste consumption, Marija and Stefan would need to choose more eco-friendly products. They would like to see different types of products which they can buy in the grocery store, as well as some generic examples like switching from plastic cutting board to a wooden one or avoiding plastic straws and using metal or glass ones.
- **Results after usage of the application:** The couple has decreased their

consumption of waste in the household. They track the progress in the application, as well as by noticing that they do not throw out garbage every single day. Based on the knowledge gathered, they now opt for more sustainable products with less or without any plastic packaging.

– **Key features for these users:**

1. Waste Calculator which would be more interactive.
2. Tips and tricks on managing waste in the household.
3. Progress tracking to see that the waste is lowered with time.
4. Eco-friendly alternatives to the products with plastic packaging.

- **Use-Case 2 – Executive Professional:** James is a forty-five year old professional which is an executive in one of the most profitable global insurance companies. He is working long hours and frequently travels for business, meaning he has limited time as a constraint. However since he has a bigger budget, he is prepared to invest in products which are from finest quality but due to his limited time he struggles to track waste consumption and build eco-friendly habits. He is living in a spacious apartment alone which therefore means he has plenty of storage and space. The use-case scenario is designed on the following use-case diagram which can be seen in Figure 14.

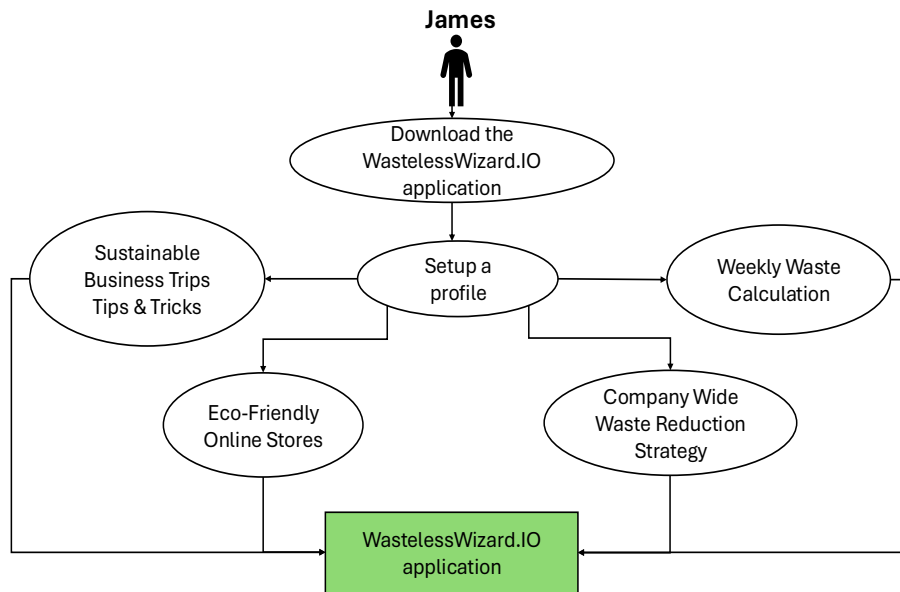


Figure 14: Use-Case Scenario for Executive Professional

- **Preconditions needed:** James has downloaded the application from the application market and set up his own profile. He desires to find practical ways

to reduce waste without having an impact on his busy schedule and to try to make his frequent business trips more eco-friendly.

– **Steps James takes in the WastelessWizard.IO application:**

1. **Sustainable Business Trips Tips:** As James is traveling frequently for work, he wants to receive business related tips and tricks which would make his choices regarding the trip more sustainable. This would mean he would receive advices how to lower the carbon footprint by opting for trains rather than flights on shorter distances, have a glass bottle for water and avoiding disposable hotel toiletries like plastic toothbrushes.
2. **Eco-Friendly Online Stores:** Due to the busy schedule and long hours in both home and physical office, James does not have too much time to browse for stores where he can find products he needs. Therefore he would need to have the option of eco-friendly online stores to be shown in order to order directly to his home and do not lose time.
3. **Company Wide Waste Reduction Strategy:** Sustainability is a hot topic in companies which want to leave a better impression on the market. Having this in mind, an executive like James would like to share the learned knowledge from the application to the company and implement certain company wide waste reduction policies.
4. **Weekly Waste Calculation:** James has a busy schedule which sometimes makes no room for any possibility of time lost during the day. Whenever he does not have the chance to put the daily products in the calculator, he would like to have the ability to put a summary for the week and calculate his impact for waste reduction.

– **Results after usage of the application:** James has started implementing more sustainable practices during his business travels without any impact on them. Whenever he is at home, he knows from which online shops he could buy products with eco-degradable or no packaging. He gathered knowledge which he could distribute further on and implement more sustainable practices on company level. By calculating his weekly summary he can track his progress.

– **Key features for this user:**

1. Sustainability tips for busy professionals and guidance during business travels.
2. Eco-friendly online shop recommendations.
3. Company wide sustainability strategy implementation
4. Weekly calculation and tracking of progress made.

- **Use-Case 3 – Student on a Budget:** Anna is a twenty-two year old student of Economics which is living in a student dormitory in the second district in Vienna. She

is passionate about recycling and sustainability but due to living on a tight budget and with limited storage space, she struggles to adopt eco-friendly habits. Her idea from the application would be to reduce food and plastic waste while saving money. Since she is living in a dormitory, she does not have too much space for storage but she has a small kitchen inside the room. Important to note is that her budget is very tight. The use-case scenario is designed on the following use-case diagram which can be seen in Figure 15.

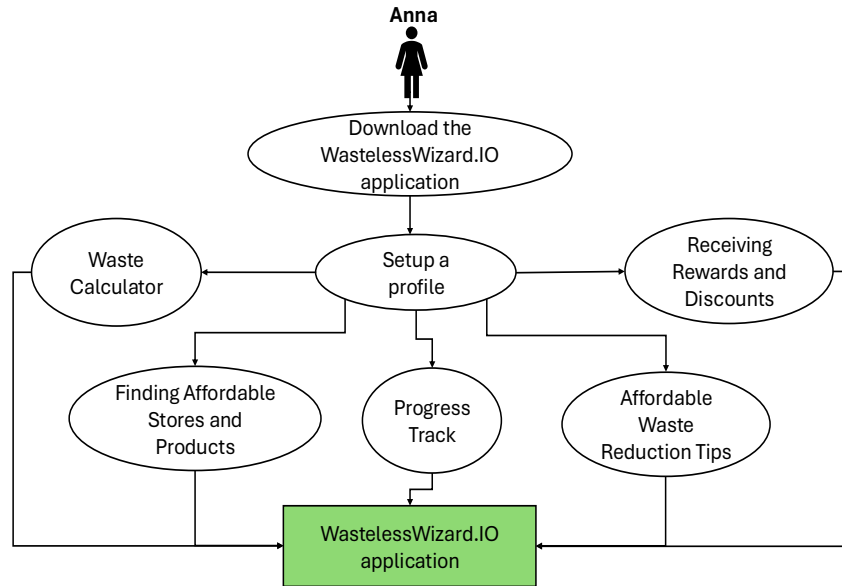


Figure 15: Use-Case Scenario for Budget Student

- **Preconditions needed:** Anna needs to download the application from the application market and create a profile. She is having limited budget and storage space, therefore she strives to receive low-cost and practical solutions which target waste reduction.
- **Steps Anna takes in the WastelessWizard.IO application:**
  1. **Waste Calculator:** Anna starts using the application by logging in the products she bought from the supermarket, while the application is calculating her waste footprint.
  2. **Finding Affordable Stores and Products:** In order to fit her tight budget, Anna needs to find stores which would not bring too much cost to her monthly financial plan. She searches in the 'Eco-friendly Stores' for cheaper second-hand shops, refill stations and bulk shops near her dormitory

or campus. She needs to find the shops near her current location where it would be specified what the stores offer.

3. **Affordable Waste Reduction Tips:** Since Anna has limited storage space, she needs to receive money and space saving tips and tricks which would be sustainable. For example, how to repurpose certain items like use glass jars for containers, do batch cooking to use the food bought in total and create cheaper DIY cleaning products like baking soda and lemon juice to remove stains from pans.
  4. **Receiving Rewards/Discounts:** As the budget is tight for Anna, she would also like to receive rewards based on the impact she makes in the application. These rewards can further on be claimed with partner stored for certain discounts on products.
  5. **Progress Track:** The application helps Anna in her desire to reduce waste by showing her the progress she made. In case she does not have time to log the products or forgets to use the application, gets reminded with the nudges sent.
- **Results after usage of the application:** Anna Klaus is reducing waste while sticking to her budget by practicing the tips and tricks received. Learns about affordable products and stores near her desired locations and adopts long-term sustainability habits without financial burden. She tracks her progress and gets rewards which makes waste reduction fun and interactive.
  - **Key features for this user:**
    1. Sustainability tips, tricks and eco-hacks which are budget oriented and easily implementable.
    2. Map with second-hand shops, refill stations, bulk products and affordable shop.
    3. Waste and progress tracking to measure waste saving.
    4. Rewards which lead to discounts on products from partner stores.
- **Use-Case 4 – Busy Married Parents with Baby:** Valentina and Goran are a married couple which five months ago welcomed their baby boy Marko. Both of them are thirty-one years old and come from different professional backgrounds. Valentina is a project manager currently on maternity leave and has limited time frame in order to do proper research. Goran is a diplomat and also has limited time to do proper research. They expect the application to give them the stores which are closest to their home where they could find products coming from non-toxic materials, with explanations what the stores offer. Additionally, they strive to educate themselves on how to create a household where only products from natural materials will enter and possibilities where they could donate things they do not need. They have a comfortable budget, not enough time and spacious apartment with space to store.

The use-case scenario is designed on the following use-case diagram and can be seen in Figure 16.

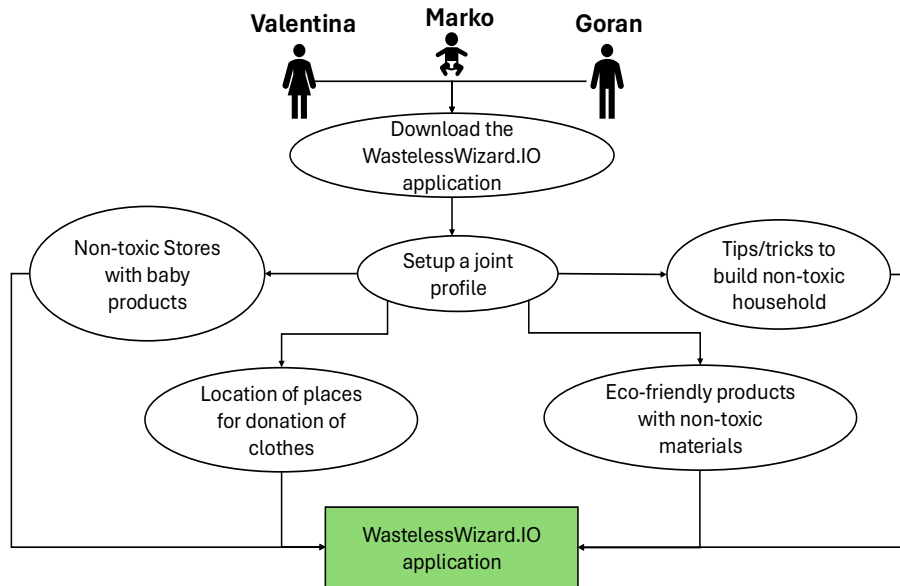


Figure 16: Use-Case Scenario for Busy Parents with Small Baby

- **Preconditions needed:** The married couple downloaded the application from the application market. Both Valentina and Goran agreed that they will setup a joint profile in the application where Valentina will be able to educate herself on what products are non-toxic for her baby and Goran will be able to quickly locate where he could buy those products.
- **Steps Valentina and Goran take in the WastelessWizard.IO application:**
  1. **Stores which offer non-toxic products for their baby:** The parents have limited time to research stores on the Internet where they could find non-toxic products for their baby. Therefore, they would use the application in order to learn which stores based on their apartment location offer such products. Having such a list of nearby stores with clear explanations of their offerings could help Goran and Valentina to make informed purchasing decisions without spending excessive time on research.
  2. **Products which are with non-toxic materials:** As every parents, Valentina and Goran want to ensure that the environment and household their baby is living is safe and healthy. In order to do that, they want to avoid buying products which contain harmful chemicals. They require

guidance on selecting more safer alternatives and having a curated selection of non-toxic products can help them to make safe and non-toxic choices for them and their baby quite quickly and efficiently.

3. **Map of places where they can donate clothes:** Valentina and Goran would need such a feature as first the clothes for their baby do not have a big life range since the baby is constantly growing. In order to not overload their household with items they no longer need or Marko has outgrown, such a map would save them time in order to help them quickly locate places where clothes can be donated. Additionally, donating is aligning with their goal to make the household even more sustainable as those items will be given a second life.
4. **Tips and tricks to build a non-toxic household:** Having such a feature will further on help the couple to get education, knowledge and awareness on how to create a safe and healthy environment for their family. Such practical guidance through tips and tricks sharing can help the couple to get educated on natural materials, show how DIY cleaning products are made and offer sustainable swapping choices.
  - **Results after usage of the application:** The couple has completely remodeled their household and created a non-toxic space. They are educated on which products do not offer harsh consequences for the nature as well as for their baby. With the possibility of product education and detailed description of the eco-store inventory, the couple can quickly shop their desired products in stores located in their vicinity. Additionally, they are making progress by repurposing already worn out clothes by donating them.
  - **Key features for these users:**
    1. Well explained types of stores in their close location.
    2. List of non-toxic products which can be used for their baby.
    3. Tips and tricks on creation of a non-toxic household.
    4. Container locator where already worn out or small items from the baby can be donated.

### 4.3 Application Features

WastelessWizard.IO as an application has a primary focus to help its users to consume less waste in their households. In order to achieve that desired goal, there are several useful practices implemented in the application through features. These practices are simple features which should serve to a benefit to the user and which should make the WastelessWizard.IO application to be more addictive. The features range from user profile creation, user management, waste calculation, progress tracking through points, knowledge and awareness gaining through useful facts, insight into sustainable and more eco-friendly

options for products as well as stores and small daily tips which have the power to build and maintain healthy habits. All the features which are implemented in the WastelessWizard.IO cross-platform mobile application will further on be explained deeply following in this section. In Figure 17, the logo of the WastelessWizard.IO is attached which symbolizes a recycling wizard through a wizard cap on top of a recycling symbol.



Figure 17: WastelessWizard.IO Logo

1. **User Feature** – The first feature which the user would use as an entry towards the WastelessWizard.IO application is the **User Feature**. This feature serves as a gate on the path of the user towards all other features which any application is offering. After the user downloads the WastelessWizard.IO application from AppStore or from PlayStore and the application icon appears on the users screen, the next thing the user would need to do is start using the application. The User Feature in the waste reduction and calculation application is providing a seamless and a very secure way for the users to first access and manage their accounts in the application. This feature is one of the crucial ones as it provides access to personalized experience, where the users would be able to track their waste management on a daily basis, would further be able to receive recognition and they would be able to gain knowledge on interesting topics which can be useful to apply in their everyday habits. With the enabling of authentication, customization of each profile and with a tracking of the progress made, this feature is focusing on enhancement of user engagement. This feature is consisting of three different component screens - the **Login Screen**, the **SignUp Screen** and the **User Profile Screen**, each targeting a different function which will be explained in a broader manner. The Login and the SignUp components can also be seen from a business process modeling side described in the **User Flow diagram** visible in Figure 18.

- **Login Screen** – The Login Screen is the first screen appearing when the user opens the application. This screen and functionality is service as a gateway

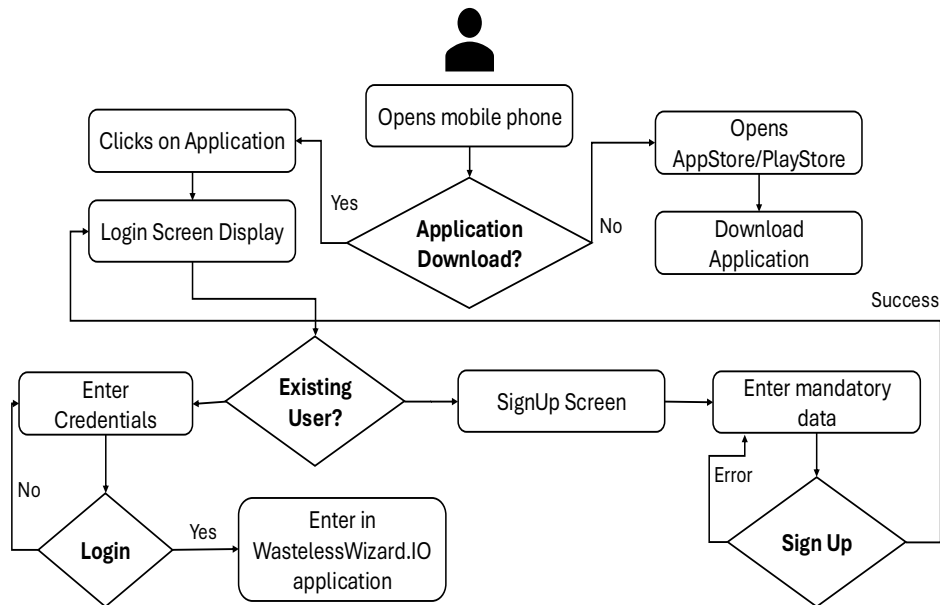


Figure 18: User Flow Diagram for Login/SignUp components

towards the application and it is allowing the users to access their accounts in a secure way. The functionality consists of the logo of the WastelessWizard.IO application which is followed by a welcoming message. Following are the fields for entering the username and the password. Once the username and password are typed, the user can click on the 'Login' button which is further sending a request towards the backend of the application, checking whether the user has an account already stored in the database. If the user has an account and the credentials for the username and password are entered correctly, it means that the user is authenticated and the user would gain access to use the application. On the contrary, if the user does not have an account already stored in the database or any of the credentials entered is not recognized, the backend would return a message with an explanation which will be displayed on the screen. For further improved security, the WastelessWizard.IO application implements a password encryption. Overall, the user interface and the design for this screen have the characteristics to be recognized as simple and responsive, while ensuring the most smooth and secure functionality. The screen design can be viewed in Figure 19 and Figure 20 listed below.

- **SignUp Screen** – If the user is not an already existing user, the user would

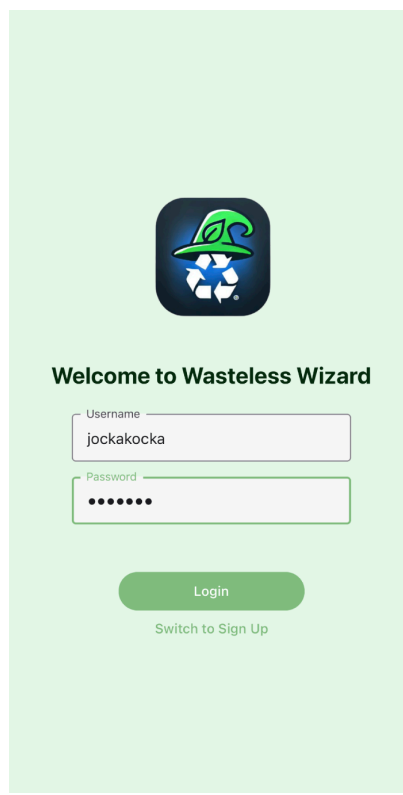
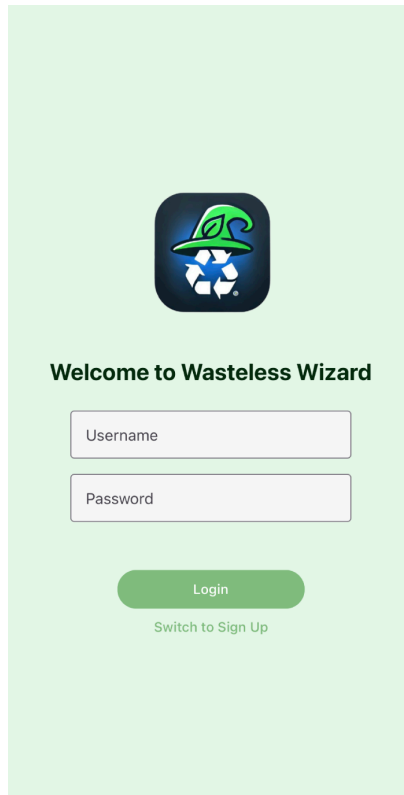


Figure 19: Blank Login Form

Figure 20: Filled Login Form

need to register and create an account in the application. In order for the user to register and create a user profile, the user would have to click on the button 'Switch to Sign Up' which would lead the user to a completely new screen. The SignUp Screen has the functionality to allow new users to register for an account in the WastelessWizard.IO application. This screen typically includes several input fields which the user would need to fill. Those fields which the user is asked to fill out contain information about the first name, last name, email of the user, the date of birth, desired username, the password and a confirmation of the password. In order for the account of the user to be even more secure, it is expected that the user would add a strong password. Once all the data is added in the mandatory input fields, the user can click on Sign Up button and if the registration was successfully completed, the user would be navigated to the Login screen in order to add the credentials and start using the application. The Sign Up screen was designed to be intuitive and to guide the users through

the process of registration efficiently, ensuring that they can start using the application without any issue. The screen design can be viewed in Figure 21 and Figure 22 listed below.

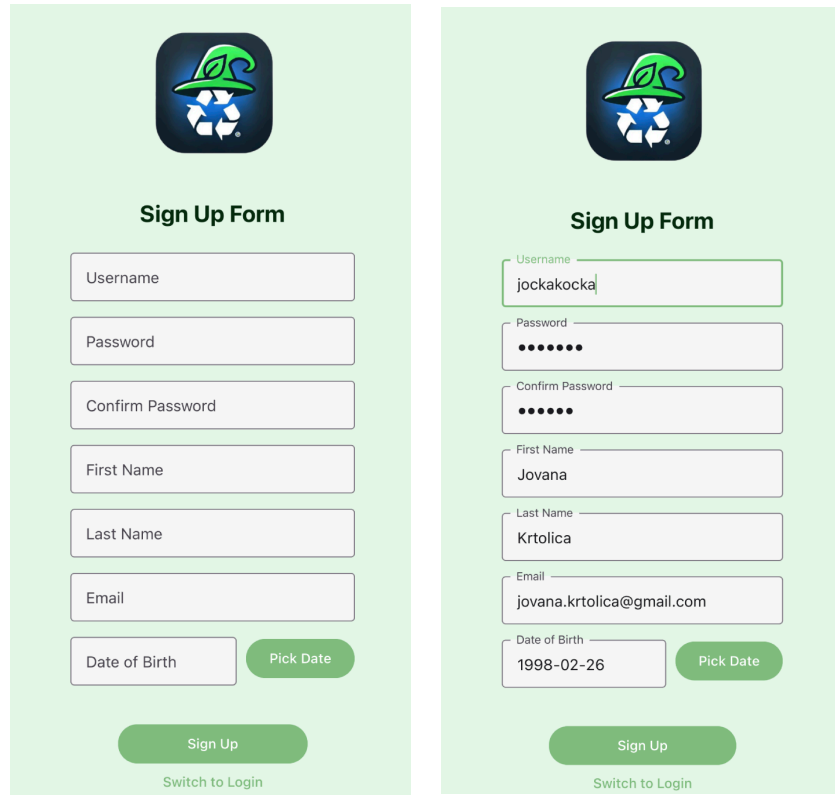


Figure 21: Blank SignUp Form    Figure 22: Filled SignUp Form

- **User Profile Screen** – In the user profile screen, the first thing the user would be able to see is some personal data. The personal data is coming from the database of the WastelessWizard.IO application where it is stored and it is showing information to the user about the name and surname of the user, the username and the email with which the user registered. The user on the screen is provided with two options for clicking. The first one is a simple one which is a 'Logout' button, which should be used in cases when the user wants to log out of the application. The second click is a button which is named 'My Waste Ranking'. As part of the research conducted on certain techniques like gamification, habit formation and self-determination theory, it has been shown that it is really important if the user actually sees the progress which the user did

by the usage of the application, as well as a score and ranking on the leaderboard of users in order for the user to feel motivated and continue to have eagerness to use the application. On the pop-up screen the user can see more information about the place of ranking the user is compared to other users and the current score which the user has, which is calculated depending on the items put in the waste calculator. A crucial data which the user can see the pop-up screen is data regarding how much waste the user saved, shown in grams. The calculation is done based on the input added in the 'Waste Calculator' feature. If the amount is in positive, it means the user is doing very good and making progress, which will result in a positive and encouraging message shown. If the amount is displayed in negative, it means that the user is still consuming products with more waste and that would result in a motivating message stating the user can try to do better. This screen is shown in the section for Game Based Learning and Gamification for Figures 2 and 3. In Figures 23 and Figure 24, the 'User Profile' screen can be seen.

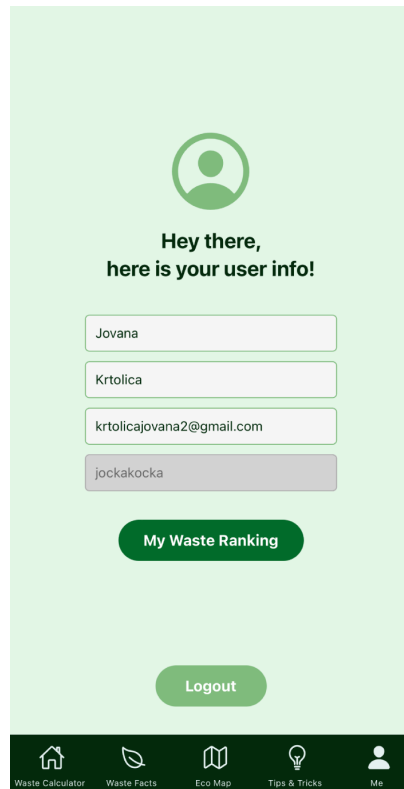


Figure 23: User Profile Feature

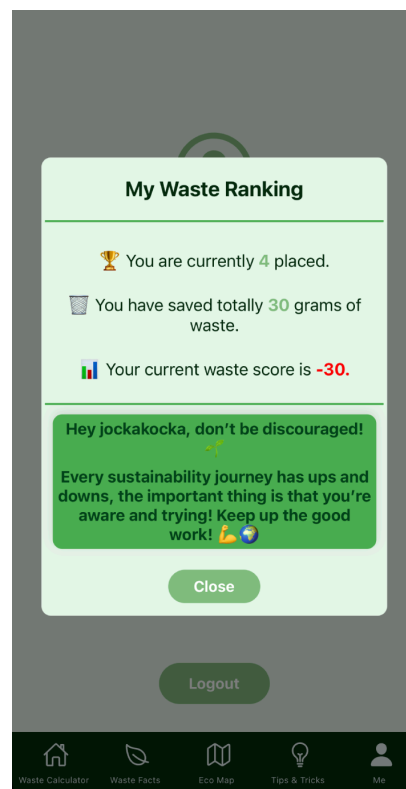


Figure 24: User Ranking

2. **Waste Calculator Feature** – One of the core features of the WastelessWizard.IO cross-platform mobile application is the Waste Calculator feature. It represents a feature which is a starting point of a positive habit formation journey for the users interacting with the application. Such a feature is crucial in the promotion of sustainable practices and habits, as well as in raising awareness for the personal or household waste consumption. The waste calculator would allow the users to keep track of the waste which they have consumed and based on the daily track the user can see the impact the user has on the environment. By the visual display of the waste consumed or the waste saved, the users can build better habits by either opting for products with sustainable packaging, reducing of products with plastic packaging or maintain the already strong habits by being determined and continue purchasing fresh products or products eco-friendly packaging, which would result in progress towards a zero-waste household.

The feature functions based on a field which serves as an input field where the user can write some keywords and there will be a list of products which contain the keyword written. The list of products is a list of hundreds of products which are stored inside the database and the products included are from different types. The range of product types is diverse and for one product there can be several options included. For example, if a user wants to input milk as product, the list will offer three options - milk in glass bottle, normal milk in regular packaging and bio manufactured milk with bio-degradable packaging. This means that the user will be offered a wider choice. Apart from the product name and type, each input is additionally containing data for two types of scores:

- **Plastic Score** – This is a score which is represented depending on the packaging material of the product. Whenever the product packaging does not contain any plastic, the plastic score would be zero grams, whereas in products with plastic packaging, the weight would be written in minus. The calculation is performed in grams.
- **Overall Ranking Score** – This is a score which is represented as an overall ranking score depending on the packaging material and the product type itself. When the product does not contain any plastic packaging, the overall ranking score will be displayed as a positive number where additionally the type of the packaging can play a role in the ranking points. On the contrary, when the product does contain plastic packaging, the overall ranking score will be shown as a negative number.

The user can add several products from the input list which would mean that the 'Total plastic saved' score and the 'Total ranking score' shown at the bottom will be combined based on the sum from all the values of each individual product. Once the user is finished and has all the products added in the waste calculator, the user can

click on the 'Apply' button which will then display the two scores. The score is then saved in the user profile ranking part and accumulated with every new entry from the user, meaning that it is recalculated depending on the entries. The recalculation of the scores can serve as a progress tracker, where the user can see on a daily basis. The idea would be that when the user would incorporate all the other features which bring knowledge and raise awareness together with the waste calculator, the user would be able to form conscious habits and try to make the score go even more in the positive scale, day by day. The higher the score, the greater the results and the more waste saved. The visualization would serve as a motivation and trigger to the user in order to encourage behavioral changes which would contribute to overall waste reduction first at an individual and then on a community level. In Figure 25 and Figure 26 listed below, a calculation performed in the waste calculator can be seen where both of the scores are in negative and in positive.

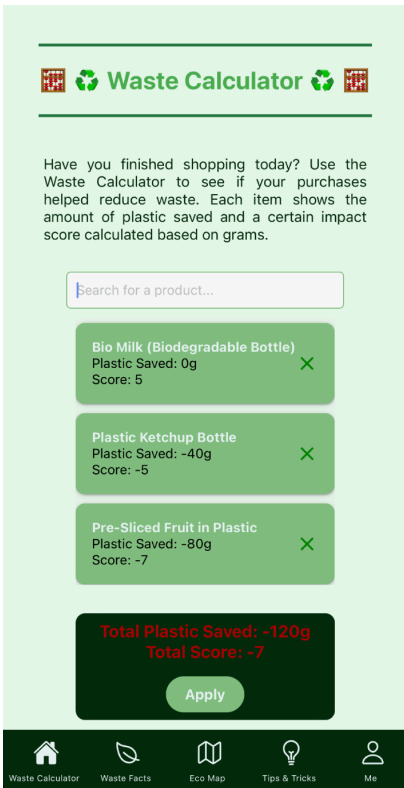


Figure 25: Waste Calculator

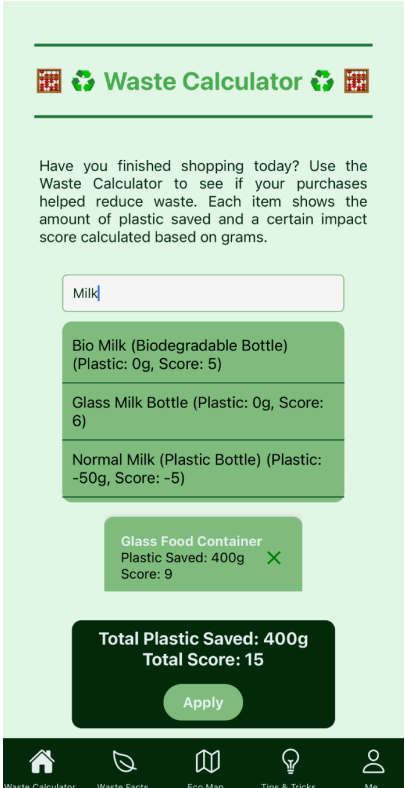


Figure 26: Calculator Input

3. **Tips and Tricks Feature** – When the participants were asked in the research

questionnaire a question about what do they think would bring positive value to the community or what feature would be useful if it is implemented inside WastelessWizard.IO, majority of the participants included in the questionnaire answered that they would appreciate if they could get some small tips and tricks steps on how to avoid consuming too much waste. That is why inside WastelessWizard.IO the feature called **Tips and Tricks** has been implemented.

The purpose of this feature is quite simple. Whenever the user navigates towards this feature, the screen will show several categories in which the tips are divided in. The division is realized in the following categories:

- **Reduce Food Waste** – In this category, the user can view tips and tricks which would help him to minimize the waste of food. In order to reduce food waste in the household, the user can do smart planning and shopping, store food properly, do creative recipes and use leftovers wisely.
- **Minimize Single-Use Items** – In order for the user to minimize single-use items, the user can always choose to buy containers in order to store food, buy a water thermos, buy products in bulk or use reusable bags.
- **Recycling and Repurpose** – For recycling, the user would need to properly divide waste and check which materials can be recycled. Before throwing out for recycling, glass jars and bottles could be reused as containers. Old or really worn out t-shirts could be repurposed as cleaning cloths or even turned into tote bags.
- **Smart Shopping** – Avoid fast shopping stores would be the first rule. Try to build a capsule wardrobe where items can be combined. Shop natural and non-toxic materials like cotton, linen or silk which feel light on the skin and are breathable.
- **Opt for Sustainable Products** - Always check for sustainable options.

Once the user expands any of the categories, a tip and trick will be shown from that category. The tips and tricks are refreshed on a daily basis which means that the users would get fresh knowledge on a daily level. The purpose of this feature is to provide learning and knowledge to the user. These guides would help the user to gain significant insights and knowledge while raising the awareness. The insight and the knowledge would then be used and put into practice when the users does supermarket, home or clothes shopping. Additionally, the higher awareness would contribute the habit formation of consumption of less waste of the user.

In Figure 27 and Figure 28 the feature Tips and Tricks is shown once the user navigates towards it. The user has the possibility to view tips and tricks which are labeled based on one of the categories listed above. The tips and tricks are showed one per category

and they are changed on a daily basis, in order to keep the user more engaged in the learning phase.

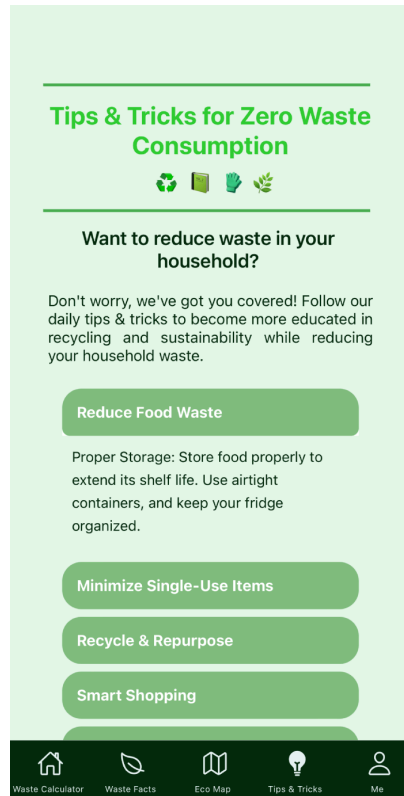


Figure 27: Tips and Tricks

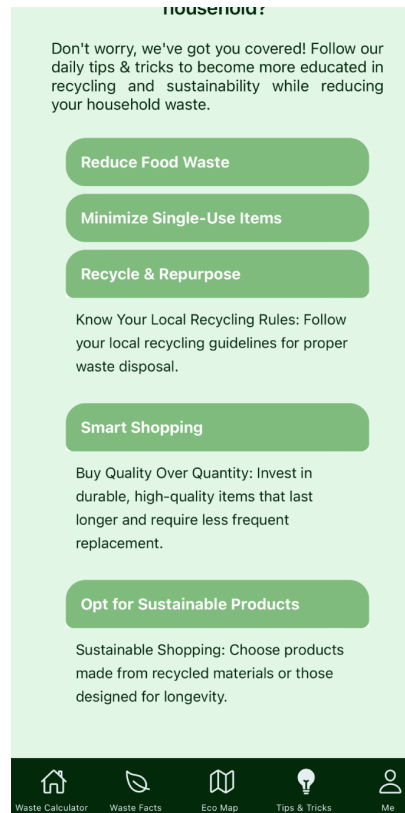


Figure 28: Tips Categories

4. **Eco Map Feature** – Following the answers received from the research questionnaire, the participants have stated that they would like to see a feature in the WastelessWizard.IO application which would propose products which have eco-friendly packages and a feature which would show a map with stores which offer food without packaging. As these answers were also appearing in the answers quite frequently, it is clearly visible that such features would be helpful to the users and make WastelessWizard.IO application more used.

That is why inside the WastelessWizard.IO application, there is a feature called **Product List and Store Map**. The Product List and Store Map feature has an intention to give to the users as a first intention a list of products which are manufactured using healthier materials, in factories which are allowing human conditions for work, are

more eco-friendly to the environment and are not toxic to the health of the individuals and as a second, it provides the users a list of stores which offer bio products, products with bio-degradable packages, non-toxic products, fresh products or products with less packaging. When the users navigate to this feature on the screen, the feature will be divided in two parts:

- **Eco-friendly Product List** – The Product List part of the screen will contain products from different ranges, from daily products used just in a more eco-friendly packaging, to hygiene products without toxic elements, to bio manufactured products, to clothing materials. The products included in the list would be of different types - from reusable cups, to bamboo toothbrushes, to milk, to eggs, to nail polishes, to bio-degradable phone cases and to washing powder. By showing the list of products which will be updated with time, the users would have the possibility to learn and to distinguish which products to buy if they want to consumer less waste and toxic materials in their households. In Figure 29, a screenshot can be seen when the user navigates to Eco Map which contains information on Eco-friendly Stores and Eco-friendly Products. In Figure 30, the screen when the user navigates to Eco-friendly Map can be seen where there is a list of products which are either manufactured in bio conditions, products which are not toxic to the nature and the health of the consumer and products with eco-packaging.
- **Eco-friendly Store Map** – The Store Map part of the screen contains a list of eco-friendly stores which sell products which are coming from sustainable background, fresh markets, bring no harm to the community and are a healthier option to use. This list can bring and serve only a positive value to the users of the application, as it will bring easiness in the process of shopping easier, as it will navigate the users directly to the store which is located in their district, close to their home. The first thing the user would see when navigating to this screen would be stores which are close to his current location. The stores which are close to the location of the user contain data regarding the store name, description of the offering of the store, the location with the address and the distance from the user to the store. The user has the possibility to modify the range of the distance where based on the preferences the application will show eco-friendly stores which are up to three kilometers away from the location of the user. Once the user clicks on the directions button, the user is then transferred to a Maps application where a route will be created. This is also visible in Figure 31 and Figure 32. If the user is curious about stores in other districts, the user can navigate on the button at the bottom of the page to view all other stores. Here the stores in the list will be divided based on the location of the district they are in. Outside of the division based on the location where only specialized stores will be visible, at the top of the Eco-friendly Stores screen the big supermarkets

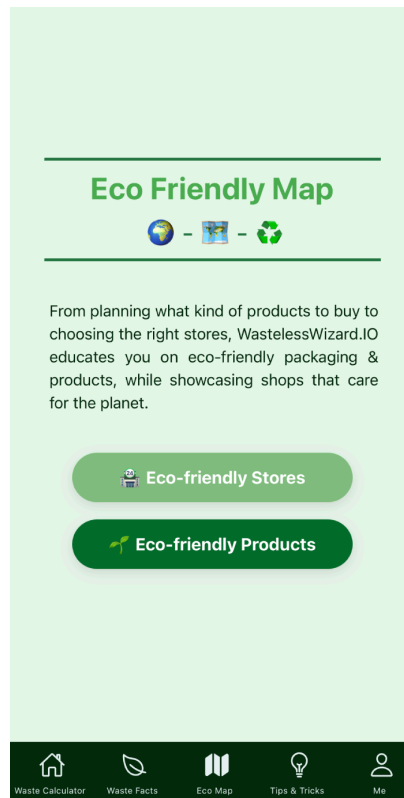


Figure 29: Eco Map Feature

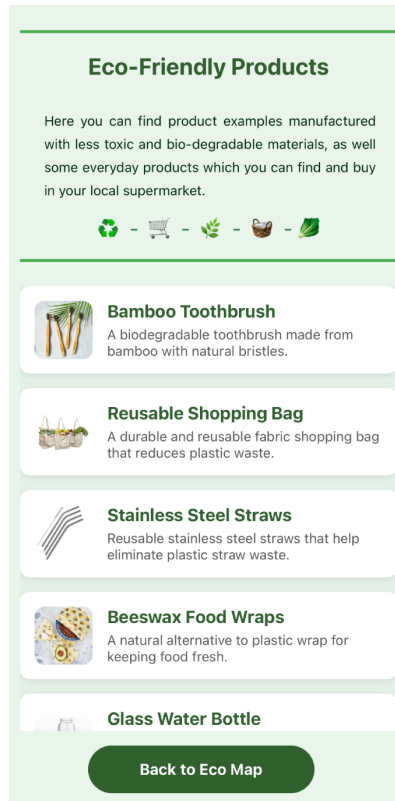


Figure 30: Eco-Friendly Products

and drugstores which are selling bio-degradable and bio-manufactured products will be listed, as they have several stores located in almost every district in Vienna. In the three following figures, the Eco-friendly Stores feature will be shown. In Figure 33, the screen when the user navigates to Eco-friendly Stores can be seen with frequent stores located in every district and specialized stores located per district. In the final Figure 34, all the stores in a particular district can be seen, as well as the precise location of the store will be displayed on Maps whenever the user clicks on the address.

5. **Waste Facts Features** – In order for the individuals to form a habit and to have self-determination towards that same habit, the individuals would need to first be aware of the root of the habit and to understand whether that habit would have a positive effect on something else. When the individual becomes aware of the behavior, the individual would strive to learn how to commit to a better behavior and how

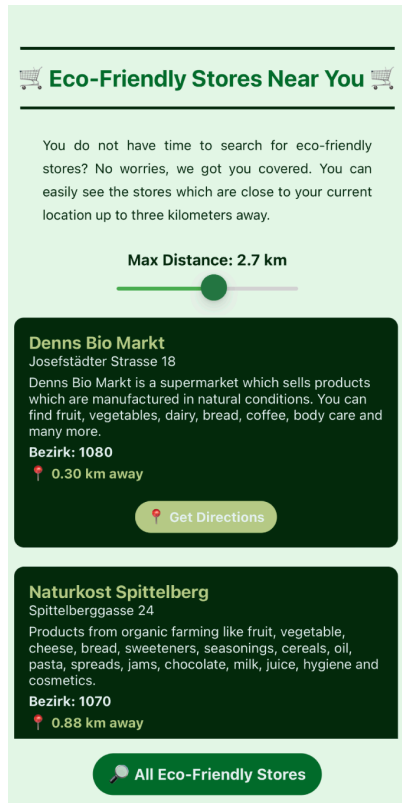


Figure 31: Eco-Friendly Stores Near You

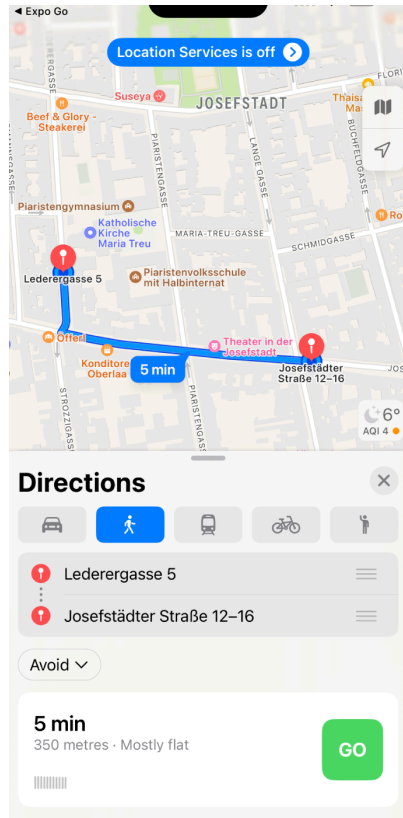


Figure 32: Map Route

to build a functional habit which the individual would master. One of the most given answers in the research questionnaire when the participants were asked how would actually an application like WastelessWizard.IO help the community to become zero-waste was to become aware. Awareness is a key step in order to fight such global problems and it is one reason why problems like this are appearing. Whenever the awareness is at a high level on a certain topic, then manipulation is lowered down and therefore the fight against the root cause of the problem is getting stronger.

So how is it possible that the community raises the individual awareness towards the global problem of mass consumption of waste? The answer is simply put by knowledge. Knowledge in any format. That is why, as one of the features of WastelessWizard.IO, 'Waste Facts' was developed. The Waste Facts feature is built to educate the users using WastelessWizard.IO on some topics which are regarding air pollution, ocean pollution, fast fashion, toxic materials, products developed in artificial conditions,

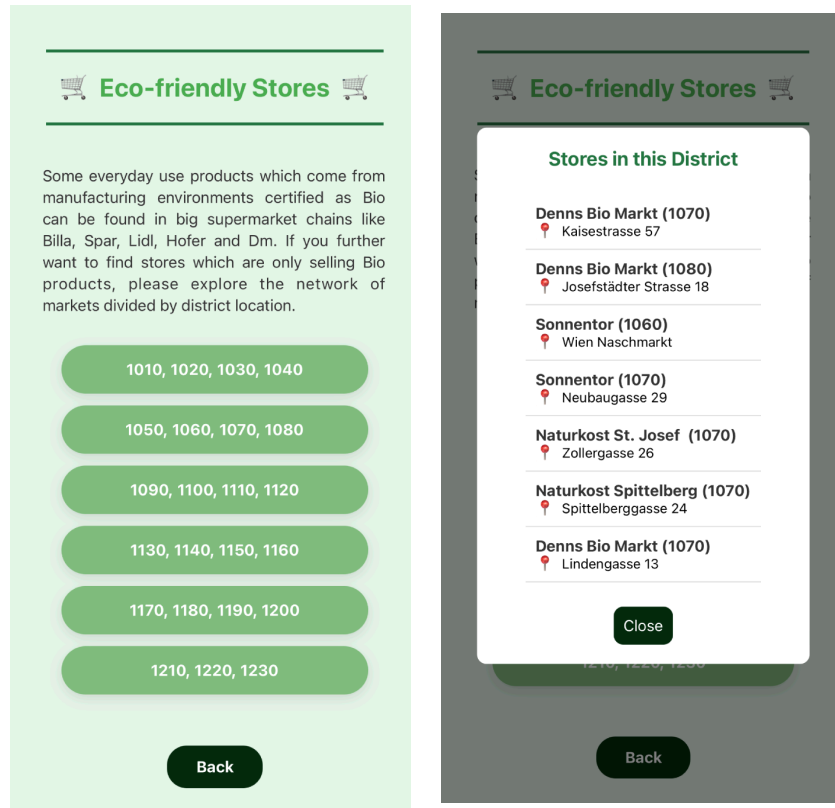


Figure 33: Eco-Friendly Stores      Figure 34: Stores in the districts

over consumption of waste, extinction of flora and fauna and mass production of food and products produced of plastic. The purpose of this feature is to educate the users by sharing simple facts which are short, catchy and offer the harsh reality. Whenever the user navigates to Waste Facts feature, the user will see on the screen five randomly chosen facts concerning topics on one of the categories mentioned previously. These facts are changed on a daily basis which will make the user even more engaged in the learning phase. In Figure 35 and Figure 36 shown below, there are screenshots of how the feature Waste Facts looks in the application on two different days.

## 5 Application Development and Architecture

After the research was already conducted and at the beginning of the development phase, it was necessary to choose the adequate technology stack, architecture and application type with all the features already identified. The final decision was that the application should

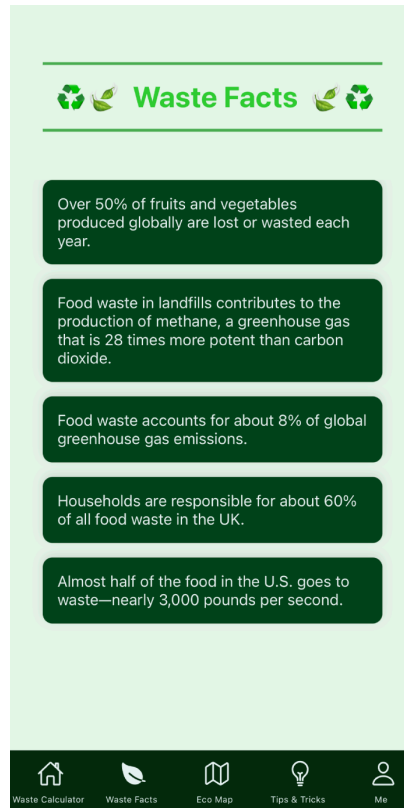


Figure 35: Waste Facts Day 1



Figure 36: Waste Facts Day 2

be built as a cross-platform mobile application. The reason why? Due to the fact that in order to make a user eager to change, the user must first become addicted. Users are already addicted to their mobile phones and newer, younger generations especially are keen on doing everything from their phones. Whether it is to pay the bills, order food, check transportation, the applications are built to make the lives of the users much easier and to solve the daily problems just with one click. That is why the WastelessWizard.IO mobile application was designed as a cross-platform mobile application which means that no matter the operating system whether iOS or Android, the users would be able to download the application from their AppStore or PlayStore. Like that, with just a click, the users could instantly start their waste reduction journey. After the application type was chosen, the next was to choose the architecture as well as the technology stack which are explained in details in the following subsections.

## 5.1 Technology Stack

In the following section, an explanation of the technology stack used during the building of the cross-platform mobile application will be discussed. The technology stack of the application is including React Native with JavaScript as a front-end development technology, Java with Spring Boot as a back-end development technology, PostgreSQL as a relational database and REST API as communication. This is visible also in Figure 37. After the

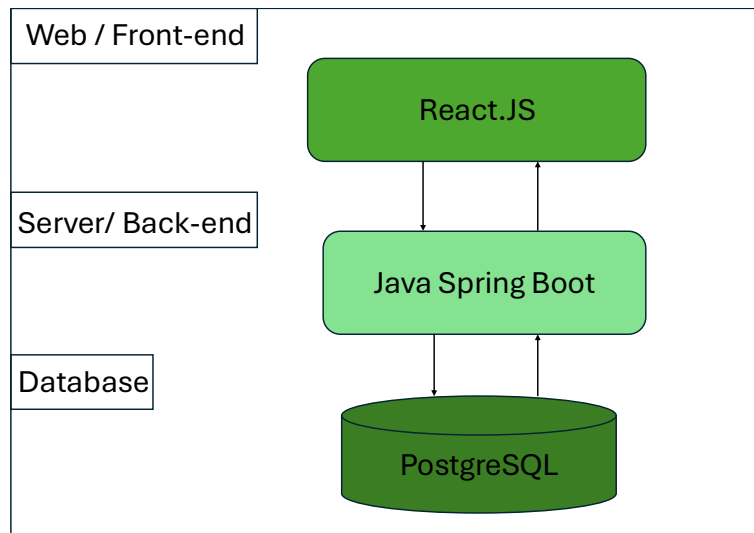


Figure 37: Visual Representation of Application Services

research was conducted, the results showed that choosing a cross-platform mobile application would be the best fit in order to achieve the results planned. The WastelessWizard.IO application is built as a cross-platform mobile application which is developed using React Native and Java Spring Boot. What this means is that React Native is covering the front-end or the visual part of the application and Java Spring Boot is used for the back-end or the engine part of the application.

- **Frontend Development:** Following the Facebook mantra which says “Learn Once, Write Any- where”, [3] React Native was chosen as a technology development stack for the frontend part. React Native represents a cross-platform framework with the use of JavaScript as a programming language, which promotes one solution that fits all sizes. The main reason behind this choice is that React Native supports cross-platform application development, meaning that the application would be available for use both on Android and iOS devices. Another benefit that React Native brings to the table is that the application is automatically updated during run time, meaning that the users can see the changes without needing to re-launch the application. React Native provides considerable benefits in terms of faster development and cost efficiency [45].

It is ideal for projects like the project conducted in the master thesis which needs a quicker launch, have current budget constraints and aims to serve a broad audience on both iOS and Android platforms. Finally, it offers a simple, supple solution, without large complexity and with clean UX/UI design structure with the usage of libraries such as React Native Paper and Material Kit.

React Native as a framework is using JavaScript as a programming language. JavaScript is a programming language which was created as a sidekick scripting language for the programming language Java [4]. Even though the naming is quite similar, the two programming languages vary from one another by a lot of technical details. The whole syntax behind JavaScript was modified after the statement syntax of the C programming language. [4] As a highly versatile programming language, JavaScript is initially used to build and develop dynamic and interactive web and mobile applications. It is one of the most popular programming language for building easy manageable, robust and engaging applications [59]. JavaScript offers flexibility which makes the language a core technology in the area of application development, due to its large community and wide range of libraries and frameworks which offer support for the developers. It supports the architecture pattern for Model-View-Controller [18] also known as MVC architecture which enables a clear separation of the parts inside the program code.

In order to setup the React Native environment, Node.js is used in the development process, even though Node.js is not entirely involved in the running of the applications written in React Native. Node.js is helping with the package management as Node.js is including Node Package Manager also known in short as npm command. NPM offers great help in managing modules by actually downloading packages, resolving dependencies and installations of needed libraries through the command line [13]. In addition to the effectiveness of JavaScript, Node.js as well is showing to be a tool which is allowing code reusability [12] and development of fast and scalable applications. Node.js is running applications outside of the browser of the user and functions as an open-source, cross-platform environment which is ideal for building applications which need to be used across several platforms. Being very lightweight, Node.js is supporting concurrent connections due to its efficient features. With its asynchronous processing, efficient management of concurrent connections and high performance, Node.js is a favored choice for various development projects. Its cross-platform compatibility and use of JavaScript further drive its popularity [37].

- **Backend Development:** The frontend of the application is communicating with the backend of the application. For the purpose of the development of the following application, it was chosen to develop the back-end with Java as a programming language and Spring Boot as a programming framework used, due to an extensive knowledge of the technologies from the author of this Master Thesis research project, as well as from simplicity purposes. Java is an object-oriented programming language which is designed for creation of highly reliable software. As such, Java is one of the

first choices when building enterprise, web or cross-platform applications, as it orients itself on domain-specific concepts, precision, scalability while modeling standard data structures. [8]

In a the world of software development, Java is considered as highly important programming language. Compared to other programming languages, Java is offering a more user friendly approach in terms of compilation of code, debugging process and learning environment. [36] It is including the following characteristics as a programming language: [36]

- **Independent platform:** Java is an independent platform as it uses the Java Virtual Machine (JVM) in order to execute code, which allows the code to be run on any operating system as long as a compatible JVM is installed.
- **Multithreading:** Java is supporting multithreading by allowing multiple threads within a certain program to be ran in concurrent execution. This is realized with the usage of classes like Thread and Runnable.
- **Flexibility:** As one of the key characteristics is its flexibility which is realized through object-oriented design, dynamic memory management and platform independence, as it allows the developers to build reusable and scalable applications.
- **Safety:** Another key characteristic is safety which is offered through features like garbage collection, strong type checking, extraordinary exception handling and the Java Security Manager which is preventing runtime errors and memory leaks.

As an object-oriented programming language it is allowing to create modular programs. It offers very good speed of execution of the final product and big simplicity during the implementation phase, mainly with the use of injected dependencies, libraries and frameworks directly inside the code properties. [51] Java is also promoting a lot of possibilities for design pattern implementation, like Gang-of-Four patterns. These design patters are offering flexible and scalable solutions to common problems appearing in the area of software application development. [28]

Spring Boot is a Java framework which is based on Spring and it simplifies the application development, making the development faster and more efficient. It enables to develop applications which are scalable, secure and clean. With its dependency injection mechanism, Spring promotes loose coupling between different components in the application. Spring Boot has a widely accepted usage rate of 62 percent [39] within the computer software industry. The most significant thing about the Spring framework is that the application can be ran with very minimal configuration which is making the development [22] of the standalone application a lot easier. It offers as well the possibility to use microservice architecture, supports multithreading and

can handle large volumes of data which makes it a fit for the Big Data industry. The highlight of this framework is the Spring Boot Initializer which is a project initializer offered by the framework. This features makes the whole initialization super easy and fast, where the user selects the common dependencies, resources and chooses between Maven or Gradle. All the selections done are then generating a starting POM file which can further on be adapted by the developers needs. [23] Spring also introduces the concept of dependency injection, which means that all the dependencies are already injected in the code. It presents a design pattern where one object is being a dependency on another object [66].

- **Communication:** In order for the data to be transferred from the backend to the frontend, each application should used a certain communication principle. The communication is realized through the usage of web services which usually ranges between SOAP/WSDL web services and REST APIs [48]. SOAP relies on a lot of standrds, while for the use cases presented in the WastelessWizard.IO application, the usage of RESTful APIs has shown to be a better fit. Inside the application, the front-end is communicating with the back-end through the usage of REST API. RESTful APIs manage a communication through the usage of HTTP requests in order to perform standard database operations like creating, reading, updating and deleting records. The mentioned database operations are also known as CRUD operations. When the user in the front-end clicks on a button or on a form, the click triggers a request which is sent towards the back-end. The back-end then takes this request, works with the database and then returns back a response loaded with data to the front-end which is visible on the users screen. REST also known as 'Representational State Transfer' [48] is actually an architecture style and it covers several core principles like the following:
  - **Statelessness:** The interactions which are happening between the API and the client are stateless which means that each request is having all the needed information inside itself.
  - **One Interface:** Resources are accessed using the standard HTTP protocols which help perform the standard CRUD operations. Those standard HTTP protocols are GET, PUT, POST, DELETE and several others, which additionally return a status code of the the status of the operation.
  - **Resource Identification:** Each resource in REST is unique and therefore addressable with its own Uniform Resource Identifier (URI).
  - **Hypermedia Usage:** In REST, resources can be related to one another by creating links which allow easier navigation.

Inside the WastelessWizard.IO application, the previously mentioned HTTP protocols are used in order for the CRUD operations to be performed. Once the user interacts

with the system from the frontend interface, the controller inside the controller layer is performing the HTTP protocol which further on is calling the service layer to perform a certain function on the database. For example, whenever a new user opens the application for the first time, the user would need to create a new user profile. This is realized in the backend by calling the POST HTTP method under `/users/create` which will take the object for the User as a request body in order to create the user inside the database. This is also visible in Code Listing 1 which shows a snippet from the code.

Listing 1: HTTP POST API Method

```
1 @RequestMapping(value = "/create", method = RequestMethod.POST)
2 public User createUser(@RequestBody User user) {
3     System.out.println(user.getFistName());
4     return userService.save(user);
5 }
6 }
```

Another example would be by using the PUT HTTP method. Lets take the use-case that the user has changed address of living. Then an update would need to be performed by using the PUT HTTP method under `/users/update` which will check the OAuth2Authorization and then would update the already existing object of the User with the new data entered inside the request body. This example is also visible in Code Listing 2 which shows a snippet from the code.

Listing 2: HTTP PUT API Method

```
1 @RequestMapping(value = "/update", method = RequestMethod.PUT)
2 public User updateUser(@RequestBody User user,
3     OAuth2Authentication authentication) {
4     if(authentication != null) {
5         CustomUserDetails details = (CustomUserDetails)
6             authentication.getPrincipal();
7         return userService.save(user, details);
8     }
9     return null;
10 }
```

A final example would be by using the GET HTTP method which is the most used across the application. The purpose in a use-case where the user would want to see the list of all possible eco-stores in the city of Vienna, the backend would trigger an API GET call towards `/eco-stores` which would show a list of all eco-stores objects in the city of Vienna. This example is visible in Code Listing 3 which shows a snippet from the code.

Listing 3: HTTP GET API Method

```
1 @GetMapping("/stores")
```

```

2         public List<EcoStore> fetchAllEcoStores()    {
3             return ecoStoreService.getAllEcoStores();
4         }

```

- **Database:** The final piece of the technology puzzle is the database. The database is connected to the back-end of the application. The data coming from or towards the user interface is stored in the database. Every transaction is putting a record in the data sheet through numerous interactions called queries. The application has its own database which is done as an PostgreSQL database. PostgreSQL is a modern relational database and it supports the building of complex object schemas while offering a flexible data type system. Relational databases as a concept dates back to the 1970 where it was defined as a series of data which is represented with relations with or to other data. [20]

The database system of the WastelessWizard.IO application is realized as a relational database which consists of several objects which have a relationship with one another. The database is containing six models which are labeled as class objects or also called entities. The classes inside them contain their attributes which are from several different data types like characters, integers, date and float data types. Additionally, there are relations established between the class objects which are from type many-to-many, like the relationship between the entities for User and Group, as visible in Figure 38 attached below.

As a storage manager, PostgreSQL provides transactional management and handling of database objects. PostgreSQL additionally works and performs well for large sets of data and complex objects. This database system is allowing its users to create new columns, to define relationships between objects and columns, set operations for these columns and establish customized data access methods. While this approach is effective for simpler objects, PostgreSQL recommends using procedures for more complex structures, especially those with nested layers or for components which share sub-components. [55] PostgreSQL uses in its background processes which are also familiar as demons. The purpose of these demons is to efficiently use idle processors for different sets of tasks. [55] It offers native programming interfaces for majority of the programming languages like Java, Python or .NET. With its modern structure is also included an open source database management tool called PgAdmin. PgAdmin is easy to setup during installation phase of PostgreSQL and it offers a nicely developed and not complicated user-interface. Although it is not the fastest database, PostgreSQL has the characteristic that it is the most advanced database created so far in the database industry. [6]

- **API Testing:** In order to ensure that the communication through APIs (application programming interfaces) is working properly, API testing should be performed. API testing is a crucial part of the software development cycle which ensures that the APIs

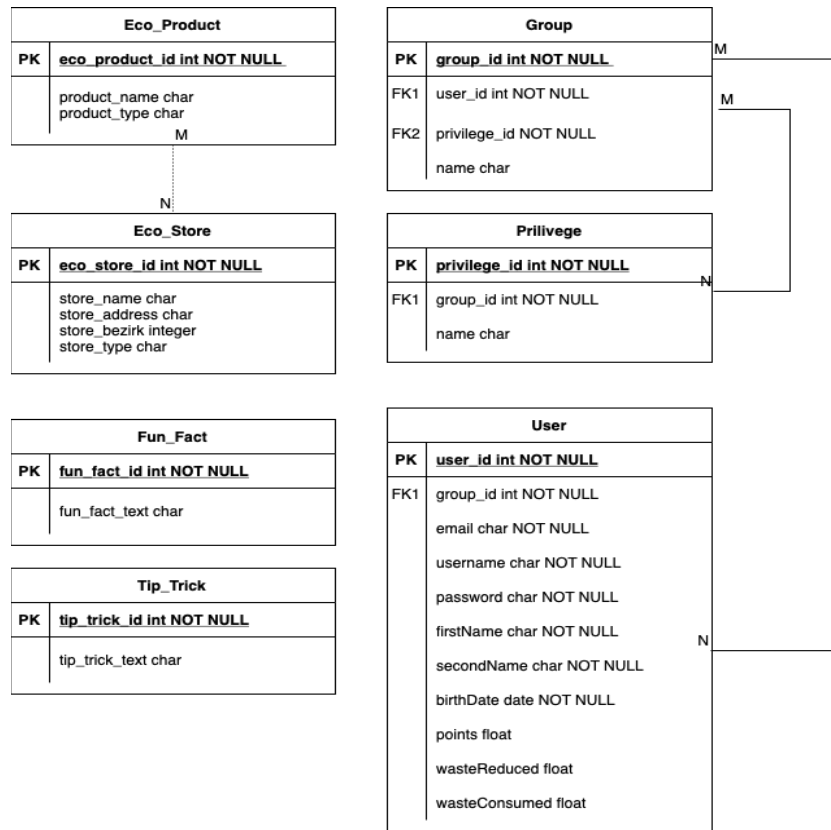


Figure 38: Database Design for the WastelessWizard.IO Application

are functioning correctly while being efficient. The process of API testing involves sending requests to API endpoints in order to receive responses which can further on be validated and verified based on performance, security or accuracy. API testing puts its focus on the business logic of an application which can help in order to identify potential problems or bugs during the development cycle. An API testing strategy needs to be well-structured with focus on key components and it can improve the software quality of the developed product by ensuring a smooth communication between the components.

For the purpose of the development done on WastelessWizard.IO, Postman was chosen as an API testing tool due to being free to use, it provides a user-friendly interface and makes the whole testing really quick. API testing was conducted continuously during the process of development in order to make sure that the responses are received and the data is transferred correctly. Figure 39 shows a GET HTTP API request which is sent towards **localhost:8080/eco/stores** which should return as a response a list of

all stores with eco-friendly products in the format of JSON objects. If the request is successful, the list would be displayed as a response with response status code 200 (OK), otherwise there will be response which based on the status code can be decoded. Such testing is really important in order to see in which format do the responses come and to see whether the communication is realized as desired.

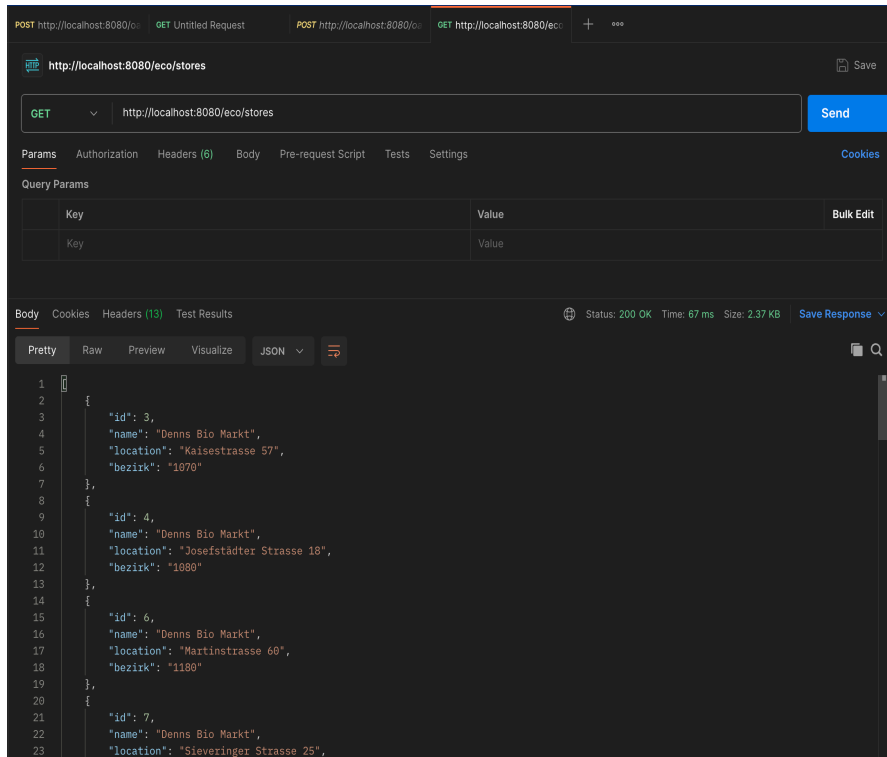


Figure 39: API Testing for GET API call for retrieval of list of eco-stores

## 5.2 Software Architecture

Before major software development starts, a suitable architecture pattern needs to be chosen in order to provide the desired functionality and quality attributes. An software architecture pattern is a general and often reusable solution which is used on a problem that occurs commonly in domain of a software architecture. Based on the research conducted, a layered architecture pattern was used as a starting point in the development phase. **Layered Architecture Pattern** was the first software design pattern after the software architecture was established. This pattern is widely used in the development of web applications, while it has a simple and easy to know structure. The pattern can decompose structured programs into groups of tasks which lie on a certain level of abstraction. In this pattern, each layer

is providing services to the next higher layer and to the one below it, meaning that the flow of information is strict. One of the most common used layers is the four-tier layer pattern shown in Figure 40. Organizing a software product into layers has been shown

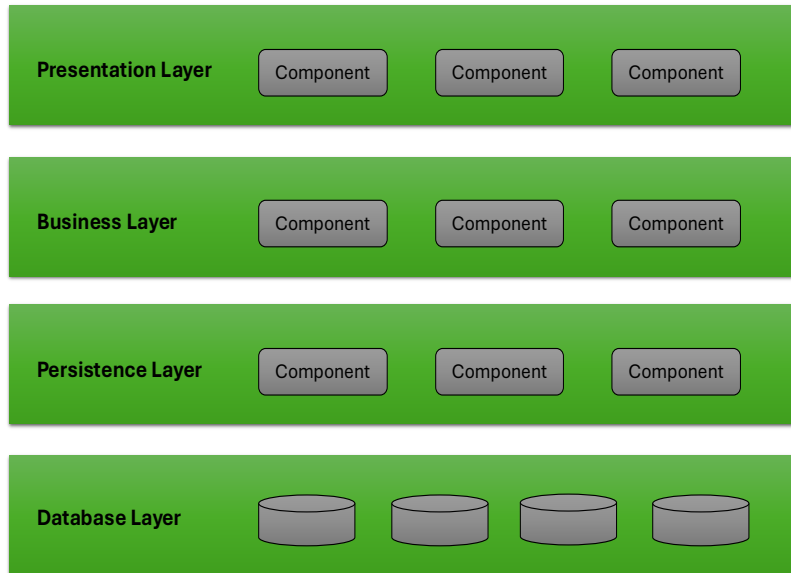


Figure 40: Layered Architecture Pattern [46]

to be the most adopted and simplest architecture pattern [52]. The layered architecture pattern is widely used in software development due to several reasons like separation of concerns - as each layer is responsible for its own function, reusability - the layers can be reused across different projects due to the consistent structure, debugging - each layer has its own function and its own testing strategy which allows the process of debugging to be simplified and finally scalability - it offers certain layers to be touched without having any effect on all other layers. [9]

The presentation layer is the top layer in the application when looking from top to bottom, which is responsible for the interaction with the end user. Inside the presentation layer, there is the client-side logic which contains the user interface components and display of the user experience, as well as the controllers which are the entry point in the logic behind the application design.

In the second layer which is the business layer, the whole business logic is stored. This layer is also known as domain layer because it is responsible for the implementation of the core design functionalities and business rules defined for the product. Inside this layer common components which can be found are services which implement specific functions and rules, data transfer objects (DTO) which are simple objects to transfer data between

layers as well as the domains which represent the key objects and entities in the application.

The third layer is called the persistence layer and this layer is responsible for the handling of the database operations like creation, updating, storage or deletion of the application objects. Usually in this layer the common components are the repositories and data access objects (DAO) which have the responsibility to do operations in order to access the database, object-relational-mapping tools which do a translation entity objects into understandable database commands and sometimes even entities.

The final layer in the layered pattern is the database layer which has the responsibility to store the data inside the database server while providing access and security. Usually the components which are found in this layer are database-management systems.

The WastelessWizard.IO application is following the layered architecture pattern with having all the layers from presentation layer, business layer, persistence layer and database layer. The communication in the layers is only realized by communication with the layer above and the layer below the current layer. The backend logic is already split inside packages, where each package is indicating its purpose. The split is done based by packages for controller, model, service and repository as visible in Figure 41. Inside the presentation

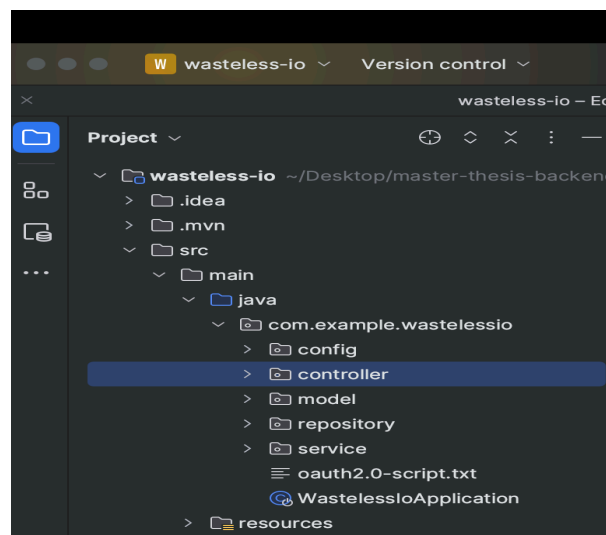


Figure 41: Layered Architecture Pattern based on Packages

layer as components are the user interface of the application as well as the controller classes from `EcoProductController`, `EcoStoreController`, `FunFactController`, `UserController`, `GroupController` and `PrivilegeController` which are the entry point towards the next layer. The presentation layer communicates to the business layer by execution of the functions inside the services which are triggered through the controllers. Inside the presentation layer, the service classes called `EcoProductService`, `EcoStoreService`, `FunFactService`, `UserService`, `GroupService` and `PrivilegeService`, as well as the domains for `EcoProduct`, `EcoStore`, `Fun-`

Fact, User, Group and Privilege are located. The business layer further on communicates with the persistence layer as the services are performing certain operations on the domain through the usage of the repository classes for EcoProductRepository, EcoStoreRepository, FunFactRepository, UserRepository, GroupRepository and PrivilegeRepository. The repositories are using and implementing the Spring Data JPA framework which uses the **extends JpaRepository function** in order to create a repository interface for a specific entity. Finally, the repositories are then communicating with the database layer in order to safely store and access the data in the database.

In the next four figures labeled as Code Listing 4, Code Listing 5, Code Listing 6 and Code Listing 7, the layered architecture pattern which is realized in the backend service of the 'WastelessWizard.IO' application is shown for the FunFact domain by showing code snippets. The code snippets are covering the FunFactController class which is part of the presentational layer, the FunFactService class which is part of the business layer, the FunFact domain class which is part of the business layer and the database layer and the FunFactRepository class which is part of the persistence layer.

Listing 4: Controller Component - Presentation Layer

```

1  @RestController
2  @RequestMapping("/fun-facts")
3  public class FunFactController {
4      private final FunFactService funFactService;
5
6      @Autowired
7      public FunFactController(FunFactService funFactService) {
8          this.funFactService = funFactService;
9      }
10
11     @GetMapping
12     public List<FunFact> fetchRandomThreeFunFacts() {
13         return funFactService.getRandomFacts();
14     }
15 }

```

Listing 5: Service Component - Business Layer

```

1  @Service
2  public class FunFactService {
3
4      @Autowired
5      private FunFactRepository funFactRepository;
6
7      public List<FunFact> getRandomFacts() {
8          List<FunFact> funFacts = funFactRepository.findAll();
9          Collections.shuffle(funFacts);
10         return funFacts.subList(0,5);
11     }
12 }

```

Listing 6: Domain Component - Business / Persistence Layer

```

1  @Entity
2  @Table(name = "fun_facts")
3  @Getter
4  @Setter
5  public class FunFact implements Serializable{
6
7      @Id
8      @GeneratedValue(strategy = GenerationType.SEQUENCE)
9      private Long id;
10
11     @Column(name = "fact")
12     private String fact;
13
14     public FunFact(Long id, String fact) {
15         this.id = id;
16         this.fact = fact;
17     }
18
19     public FunFact() {}
20 }

```

Listing 7: Repository Component - Persistence Layer

```

1  @Repository
2  public interface FunFactRepository extends JpaRepository<FunFact,
3      Long> {
4
5  }

```

## 6 Evaluation

Awareness and its conceptualization involve the definition and the understanding of how the individuals are perceiving, processing and responding to information. All these processes in regards to recieval and response of information are shaping the behavior actions and the cognitive mind of the individuals.[27] [60] Conceptualization of awareness is a strongly important part which contributes towards behavioral change, social responsibility, proper decision-making and habit regulation. As such it plays a key role in environmental sustainability and ecological mindset. Research on the topic of waste awareness is exploring the behavioral, educational and gamified driven approaches which are constantly enhancing waste awareness and encouraging individuals to adopt responsible waste management practices. In order to raise awareness on crucial points like waste, the motivation and knowledge of the individuals should be measured, in order to know where to first start acting. [14] Not only motivation and knowledge should be measured and evaluated, but also certain socioeconomic factors should be examined as they offer insights why individuals adopt certain waste separation practices. Final thing would be the educational initiatives

which should be taken in order to bridge the gap between the current and target waste management behaviors and attitudes. With the support of educational methods, as well as applications acting as games, individuals can develop theoretical understanding and skills which will reduce waste as an action. [16] All the research and the studies done on the topic of awareness and waste awareness in particular are showing that awareness is essential and primary thing in fighting any problem, but it could not function on its own as it needs to be paired with structural support, governmental policy changes, sustainability education and even useful green applications targeting the creation of long lasting waste management practices.

Before the start of the development of the WastelessWizard.IO mobile application, a research questionnaire was conducted with eighty-five participants where certain recycling practices, waste management strategies and potential useful features were identified. As a final part after the development, an evaluation of the developed application should be conducted. Evaluating the mobile application which targets zero-waste households is crucial in the promotion of waste awareness, behavioral changes and enhancement of user engagement with the sustainable eco-friendly practices. The evaluation would aim to provide meaningful information whether the mobile application brought the desired effect which is that a higher waste awareness is present in the participants. Such an evaluation should be well structured, containing questions which would target the usability of the application, user experience, insights on waste practices and impact the application has on the users in regards to adopting waste reduction practices. Without a structured evaluation, it would be very difficult to measure whether the users, players or participants are actually benefiting from the features brought by the application or whether any changes have happened in regards to waste reduction and sustainable habit formation.

In order to have a successful evaluation, fifteen participants were chosen and identified to take part of the evaluation. The evaluation is structured in two parts which are equally important. The first part is the pre-test survey which is establishing the ground basis of the players or participants awareness on the topic of waste, their habits for it and the motivation they have before using or playing with the mobile application. The pre-test results are critical in building a solid foundation of the application which will target directly the development of needed features in order to help the users reach the zero-waste households. The pre-test survey would allow a meaningful comparison with the post-test survey which is the second part of the evaluation. On the contrary, the post-test survey is targeting the behavior, motivation and awareness of the users or players after using the mobile application. The results received from the post-test questions would help to determine whether the key features implemented in the application effectively influenced the users to adopt better waste management practices, form greener habits and reach a higher level of sustainable awareness. Additionally, the post-test results gather insights in the usability of the application which can serve as possibility for future improvements. The pre-test and the post-test surveys work together by providing a before and after comparison of the users practices, waste awareness levels and their attitudes towards waste management practices.

In order to understand whether the application has practical impact on waste awareness in individuals, the statistical method called Wilcoxon Single Ranked Test is used. This type of test is used in order to get statistical evaluation, where a comparison of paired data samples is realized through the representation of before and after usage of the WastelessWizard.IO application. Both the studies are realized in a questionnaire format, where the participants could rank each statement using a Likert scale with five levels. The Likert scale is ranking the statements with values from 1 to 5 for “Strongly disagree” with 1 to “Strongly agree” with 5.

## 6.1 Evaluation Results

The evaluation consists of two surveys where one is filled by the participants before using the WastelessWizard.IO application and the other is filled post using the WastelessWizard.IO application. The study or the evaluation has a focus on measuring the awareness regarding waste consumption the participants have before and after using such an application. In order to analyze and measure the impact, a Wilcoxon signed-rank test is used for the statistical evaluation where certain data is being compared. For the needs of the following evaluation, six paired samples of statements are analyzed from the pre-test and the post-test. The six paired samples of statements can be seen in Table 2.

Statement Number	Statement
1	I believe that the waste reduction I do is having a positive effect on the environment and the planet
2	Reducing my household to as little waste as possible is important for me
3	I track the waste amount that my household generates
4	I know how to effectively reduce waste in my household.
5	My household consumes and produces too much unnecessary waste.
6	I know enough on the topic of achieving zero-waste households.

Table 1: Paired Statements for Pre-Test and Post-Test Surveys

The data as answers for the statements is collected from the pre-test questionnaire and post-test questionnaire where the participants are rating the statements from Totally Disagree, Disagree, Agree and Totally Agree. Having four possible options is forcing the participants to decide in case when they have a more neutral opinion. Each answer is having a rating and the values given for each statement are summed together. In Table 2 you can see with what rank are the answers to the sample statements ranked.

Each participant of the fifteen which takes part of the survey should answer the paired six sample statements and plus additional ones which differ from the pre-test to the post-test survey. Since Wilcoxon signed-rank test is used, the calculation is happening on the sum

Statement Answer	Answer Ranking
Strongly Disagree	-2
Disagree	-1
Agree	1
Strongly Agree	2

Table 2: Paired Statements for Pre-Test and Post-Test Surveys

of the signed ranks in order to determine whether there is a significant difference between two paired samples. Additionally, the Wilcoxon test does not compare the total sums but compares a paired differences for each user. Whenever the difference is equal to zero, it means that this value is ignored. In Table 3 the differences per paired question from the pre-test and post-test are given for each of the fifteen participants. The difference column is showing whether the user’s value increased, decreased or stayed the same and it is ignored.

User	Q1 Diff.	Q2 Diff.	Q3 Diff.	Q4 Diff.	Q5 Diff.	Q6 Diff.
1	+1	+1	+3	+2	-3	+2
2	0	0	+3	+3	-3	+2
3	+1	0	0	+2	-3	+3
4	+3	+2	+3	+3	0	+3
5	0	0	+4	+3	-3	+4
6	+2	0	+3	+3	-3	+3
7	0	0	+4	+3	-3	+3
8	0	+1	+3	+3	+3	-3
9	+3	0	+3	+4	-4	+3
10	0	0	0	0	0	0
11	+1	+2	+3	+3	-3	+2
12	+3	0	+3	+3	-2	+2
13	0	0	+2	+3	-3	+3
14	0	0	0	0	0	0
15	0	0	+3	+3	-2	+2

Table 3: Differences for every paired sample statements from pre-test and post-test per every user

After the differences were calculated for the paired sample statements, next to come would be to actually run the Wilcoxon test for each paired set of statements. In order to actually understand whether there is any significance from the application, there should be an interpretation of the results, therefore a  $p$ -value should be chosen as a certain threshold. The  $p$ -value is determining the statistical significance. For the purpose of this evaluation is was chosen that the  $p$ -value is less than 0.05. If the  $p$ -value is set to be less than 0.05 or

0.01, there would be a very strong statistical significance proven. The Wilcoxon test has been performed in Python where first a .csv file is loaded which contains the data received from each participant for the paired six samples in the pre-test and post-test surveys. After performing the Wilcoxon test in Python, the median of the pre and the post values needs to be compared, in order to interpret whether the post-test scores improved. If the post-test median is bigger than the pre-test median and the  $p$ -value is smaller than 0.05, it means that the post-test scores have improved significantly. Whenever the change is negative, it means that the post-scores are showing worse results and it means the application did not bring the results desired. If there is no significant difference and the  $p$ -value is bigger than 0.05, it means the change is not statistically meaningful. The results from the Wilcoxon test show that all the tested paired samples are meeting the statistical significance, proving that there is evidence that there is change in the users thinking, habits and awareness regarding household waste after using the WastelessWizard.IO application. The difference is shown to be especially significant in the sample statement for the tracking of waste, effectively reducing of waste and knowledge regarding waste. In Table 4 the Wilcoxon test results including the pre-score, post-score, change and the  $p$  value computed for the six paired samples are shown where the  $p$ -value is less than 0.05.

Paired Statements	Pre-Score	Post-Score	Change	$p$ Value
waste_reduction_positive_effect	0.67	1.60	+0.93	0.016351
reduce	1.20	1.6	+0.40	0.063318
track	-1.13	1.33	+2.47	0.001316
effectively_reduce	-1.20	1.33	+2.53	0.000796
consume	0.93	-1.40	-2.33	0.001316
knowledge	-1.00	1.40	+2.40	0.001214

Table 4: Results from pre-score and post-score for every paired statement with the change

The evaluation additionally contains questions which are asking regarding the usability of the application. Including questions which are targeting the usefulness and effectiveness of the application built is essential in order to gain understanding how well the application is meeting the needs of the target audience and it also supports the waste reduction goals and helps the audience built sustainable waste habits. These questions would help in the receiving of direct feedback regarding the features and would serve as a basis ground for future improvements and enhances. Such insight is crucial for refining the application design, enhancement of the user experience and making sure the application is providing long-term influence on the topic of waste reduction in the households. From the answers received, the users are positive the WastelessWizard.IO is very-effective for waste reduction and that they would continue using the application, as well as recommend to other people to use it. As part of the question which is aiming to gain insight for possible improvements, part of the participants in the post-survey have stated the following:

- **Adding more challenges and a rewards system.**
- **Possibility to connect with like minded people.**
- **Enhancement of the user-interface of the application.**
- **Enrich the list of stores and products.**
- **Make the application available in AppStore and PlayStore.**

## 6.2 Discussion

The evaluation conducted is proving and indicating that the WastelessWizard.IO is positively impacting towards waste awareness and sustainable practices to reduce waste in the household. The Wilcoxon signed rank test is proving this by providing results which show that the participants were influenced by the WastelessWizard.IO application. Overall, the evaluation is providing the empirical evidence which is supporting the positive effect of such an application which is supporting the development of sustainable eco-habits, the raise of the awareness of the people towards products made from eco materials and incorporation of practices which would lower the waste consumed in the household, therefore aiming to create a zero-waste household.

The evaluation is showing that the WastelessWizard.IO application is having a strong effect on the tracking of waste in the household, as the change is quite high. After the participants have played the application, they started tracking the waste they consume in their household either by checking how often they throw trash, use the calculator or practice the tips and tricks provided by the application. Additionally, the evaluation is proving that after the participants played the WastelessWizard.IO application they felt like they got valuable knowledge and insight on how to effectively reduce waste in their household, whether it is from the tips and tricks, shopping from eco-friendly stores or opting for eco-friendly products made from non-toxic materials. The study is further helping the knowledge and awareness raising as the participants have felt that they gained a lot of valuable knowledge on how to effectively reduce and lower the amount of waste consumed in their household. Even though the change for the statement targeting the users thinking on whether they think they consume too much waste in the household is showing to be in negative and therefore not bringing a value, it is showing like that as the answer which holds the highest would be Strongly Disagree. This would mean that actually the participants do not consume too much waste in their household and therefore the negative big change is proving exactly that point.

The participants in the evaluation also brought insightful feedback in regards to further improvements. Some of the answers which were received were repetitive, especially in the context of rewards system, leaderboard and challenges. Such thinking is showing that the already gamified approach of the application is bringing a lot of effect, but the inclusion of gamification strategies like challenges or a rewards system would further more enhance the

usability of the application and attract even more users to it. What is also interested to note is that the participants would like to have the possibility to connect with like minded people which shows that the reward for certain participants would be when the community actually sees your actions. This is relating to the practices which are implemented as part of the self-determination theory.

The study showed from all the participants a very positive and encouraging feedback. Overall, the participants feedback showed that the application has high potential in solving this very important and concerning topic, while most importantly distributing knowledge and broader awareness for the topic of reaching zero-waste households.

## 7 Future Work and Conclusion

The fields of sustainability and conscious waste management are fields which will continue to evolve even more in the future, as there is already a lot of focus and attention which is regarding problems, topics or concepts from these fields. Both fields are part of the everyday life of each individual and the problems which they offer solutions to will even more be reflected through rapid global warming changes.

Since the WastelessWizard.IO application has already several features which would offer practical steps for the users and individuals to reduce the waste intake in their households, the next direction for further work would be to make a more extensive research of what the users would also find to be useful as a feature to be integrated inside the application. As part of the research questionnaire, several of the participants gave they answer that it would be very useful if the application would offer a map where the location of the waste containers would be shown and the containers would also be labeled based on the type of waste they are collecting. This would be a significant direction for future development as it would mean that further educational as well as actionable features are going to be integrated in the application. A waste container map could cut down the time of the investigation of the user, where the data and the location will be directly provided in the application and the user would just need to come to the location. It will serve as efficient time-management tool because everything will already be ready and the user would only be left to stay consistent to the correct waste division.

The integration of such a feature can further more be a basis for the research of another integration which would be a feature which would serve as a waste exchange market. The waste exchange market could be realized and developed as a platform where the community can additionally contribute towards the zero-waste way of living by donating items which are of no use for them, swapping products or even sell some products for a relatively low price. Such a feature can have a positive effect on the community as over-consumption would be lowered down by simply extending the life use of the unwanted products in our households.

Such a platform can further be integrated with some of the techniques mentioned in the

research like gamification where each action would come with a positive reward. This would further be an area of improvement where the application would create a tailored gamification reward system with the use of badges, challenges, awards and ranking. All the action which is done in the application could serve as a possibility to gain awards which would mean more badges and higher ranking score. The application could then form partnership with eco-friendly stores or with similar platforms which are following the same mantra. From the formed partnerships, the users with a certain ranking level or with certain points could gain discounts in the eco-friendly stores which would boost the engagement of the users with the application and would help in the forming of long-lasting recycling and sustainable habits. The participants in the research questionnaire also gave their recommendation that such applications need to partner up with the local municipalities and the government in order for the application to target even better results. Such partnerships could further on impact the use of the application as the application could be promoted as one of the governmental services which can be further integrated with the government organizations for waste collection.

The final paths of the future work improvements would be to make the application available first nationally wide in Austria and then to turn the application to be global. Going global would mean that the application would gain far more users and the architecture, design and development would need to be adapted in order to serve a greater amount of people. Having that in mind, it would be crucial for the application to receive funding in order for the whole idea to grow. The funding or the revenue generation is crucial for the enabling of all the mentioned enhancements, as well as for the maintenance of the development setup, which would in the end result in a smooth user experience.

All the previously mentioned advancements for community and government integration, an enhanced rewards system, waste container localization and monetization strategies, the WastelessWizard.IO application would not only make waste reduction to be more accessible but they would help in the process of creation and maintenance of long-term habit formation which would contribute to behavioral changes of the individuals which would further be a driving force towards a zero-waste society. Through the continuous innovation and global expansion, this application has a high potential to become of the leading platforms for waste reduction in the households and sustainable way of living.

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