Project Report - Challenge: Product Circularity

Team M^3 - LoopID 2

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1 Introduction

In recent years, waste production has increased tremendously worldwide with no indications of slowing down [1]. The global economy generates more than two billion tons of solid waste annually [2]. Moreover, due to growing populations, rising incomes, and urbanization, waste production is expected to further increase by roughly 70% by 2050 [3].

The expanding middle class will significantly increase consumption and, ultimately, waste disposal, straining natural resources which are currently consumed 50% faster than they can be replenished [2]. By 2030, current consumption patterns will require more than two Earths' worth of resources, and by 2050, three [4]. With such immense volumes of waste, the need for adequate waste management is more critical than ever [1].

Our team is uniquely positioned to address this pressing issue through an interdisciplinary mix of expertise, encompassing computer science, political science, and design. This diversity and combination of technical expertise with a deep understanding of sustainability, circular economy principles and design thinking, allows us to develop an innovative solution that incorporates a variety of perspectives.

Our goal is to develop a tool to extend the lifecycle of products and promote their circularity. We aim to actively contribute to combating global environmental waste issues and enhancing sustainability.

Our vision for the future, encapsulated in our slogan *'Looping the Economy'*, envisions a world where products have a significantly extended lifecycle and are seamlessly integrated into the circular economy with the support of technologies. We aim for repair and reuse of products to become the norm, thereby minimizing solid waste and its generation. Through the successful realization of our project, we strive to make a substantial contribution to sustainability by empowering both businesses and consumers to reduce their environmental footprint, with our developed solution serving as a pivotal tool in supporting this vision.

2 Problem Statement

Traditionally, waste management has followed a linear economy approach, where consumers purchase, use, and dispose of products [5]. Recent efforts to improve waste management practices often focus on the 3Rs (Reduce, Reuse, and Recycle), which still result in landfill waste and do not maximize the potential value of solid waste [2]. Furthermore, products often become obsolete or are disposed of before reaching the actual end of their physical life or economic value, resulting in shorter product lifecycles [6].

Therefore, the circular economy (CE) as a model of production and consumption has increasingly come into focus, aiming to close the loop by maximizing the value of materials and minimizing waste [7]. This is achieved by ensuring that the materials of a product are kept within the economy wherever possible through recycling when a product reaches the end of its life, allowing the materials to be used repeatedly and generate additional value [8]. Hence, the core element of the CE is the restorative use of resources, and it is designed to be restorative and regenerative, keeping products, components, and materials always at their highest utility and value [7].

Therefore, one of the main aspects of the CE is the extension of the life cycle of products through sharing, leasing, reusing, repairing, refurbishing, and recycling existing materials and products for as long as possible [8, 9]. Extending product lifetimes is a key method for addressing the problems of solid waste management and environmental pollution, as

well as reducing the depletion rate of natural resources and energy [10, 11, 12]. However, achieving these benefits also require efforts to persuade consumers to keep their products longer [10, 11, 12].

Addressing the challenges of maximizing the value of products, extending product lifetimes and promoting circularity is crucial for fostering sustainable consumption patterns and reducing environmental impact. Our project aims to tackle these hurdles by developing a solution designed to optimize product lifecycles and support sustainable consumption practices. Through innovative approaches, our solution aims to enhance product interactions and experiences, emphasizing longevity and sustainability to promote responsible consumption and environmental preservation.

2.1 Policy and Regulation in the EU

As part of the European Green Deal, the European Commission is currently drafting regulations for the Digital Product Passport (DPP) [13, 14, 15]. Specifically, the regulation aims to improve product transparency and sustainability by including detailed information about a product's lifecycle in its DPP [15].

This provided information is expected to encompass details on performance, traceability, technical documentation, harmful chemicals, user manuals and more [13]. Therefore, each product will be assigned a unique ID, entailing the specific information [15]. Specific requirements for the DPP will be drafted for each product group over the next few years, with the first implementations expected in 2026/27 [14].

2.2 The Challenge

LoopID [1], a start-up focused on unlocking circular business models, is tackling the challenge of the DPP implementation as well as its usage through their innovation, *'ProductGPT'*. *ProductGPT* allows users to chat and interact with a product's digital twin based on the information provided within its DPP.

At its early stage of development, *LoopID* recognizes the importance of identifying impactful use cases and improving their product even further. Therefore, the challenge revolves around how *ProductGPT* can support the circularity of products and extend their lifetimes. This includes identifying, testing, and validating the most impactful use case, as well as enhancing and completing features and the overall user interface and experience.

3 Concept

The goal of the challenge and our project is to develop, identify, analyze, test, and validate one of the most impactful use cases of *ProductGPT*. In order to make a successful contribution, it was initially important to explore relevant topics to create a general understanding of existing scientific findings. Therefore, the initial focus was on an extensive literature research, which allowed us to identify and define problem areas, as well as to develop concepts in accordance with *Design Thinking* principles.

Following this initial phase, we defined and developed several specific use cases that align with our objectives. After an in-depth analysis and validation process of the use cases to ensure their effectiveness and feasibility, we conducted a Phase-one Mapping Meeting with *LoopID* to further refine our use cases and ensure alignment with their goals

[1] `https://www.loopid.com`

and strategic objectives. Finally, we selected the specific use case in which we see the highest impact of using *ProductGPT*, which is presented in the following section.

3.1 Idea

In the fashion domain, the rise of fast fashion has led to an increase in both the production and disposal of clothes [16]. In 2020, the textile sector became the third largest contributor to water degradation and land use [16, 17]. Producing a single cotton t-shirt requires 2.700 liters of fresh water, enough to meet one person's drinking needs for two and a half years [16, 18].

Additionally, the fashion industry is responsible for an estimated 10% of global carbon emissions, surpassing the combined emissions from international flights and maritime shipping [16, 19]. Textile production also accounts for about 20% of global clean water pollution due to dyeing and finishing processes [16].

Each year, 92 million tons of clothing materials are discarded, with at least 57% ending up in landfills [20, 21]. Moreover, less than half of used clothes are collected for reuse or recycling [16]. A single laundry load of polyester clothes can release up to 700,000 microplastic fibers, which can end up in oceans and the food chain [16, 22]. The majority of these microplastics are released during the first few washes [16]. Fast fashion relies on mass production, low prices, and high sales volumes, which promote many first washes [16].

The promotion of a circular economy in the fashion domain can significantly reduce both solid fashion waste in landfills and the release of microplastics [16]. Therefore, we see the greatest impact of using *ProductGPT* in the fashion domain, emphasizing its potential to extend the lifetime and lifecycle of fashion products and thus help tackle these issues of fashion waste.

Furthermore, the increasing interest in regulation and sustainability aligns with growing consumer awareness of the environmental and social impacts of their purchases [23, 24, 25]. Studies have shown a demand for clothes that last longer and promote sustainability [23, 24, 25, 26]. However, brand authenticity and verification remain crucial, as many consumers distrust brand claims [24]. By leveraging *ProductGPT*, which is based on the DPP of a product, we can foster trust among consumers and address environmental challenges posed by the fashion industry.

To gain more insights and specify a possible use case, we interviewed three experts from the German fashion industry following our research to ensure practical viability: *Nina Rein* [2], *Ucon Acrobatics* [3] and *NIKIN* [4]. The details of these interviews are included in the appendix A *Interviews*. The interviews showed a range of approaches and challenges in the field of sustainability and fashion, focusing on the importance of transparency and openness about the products, innovation, ethical commitment, and dedication to the future of sustainable fashion. Despite higher costs, sustainability is crucial for maintaining moral standards in the fashion industry, stressing environmental preservation, and attracting like-minded clients.

Considering these numerous insights and potentials, we have conceptualised a use case in the fashion domain as part of the challenge. This use case can be applied to all possible fashion products and will be presented in the following section.

[2] `https://ninarein.com`

[3] `https://de.ucon-acrobatics.com`

[4] `https://nikinclothing.com`

3.2 Developed Use Case and Digital Prototype

Recognizing the need for a tool to overcome the challenges of the fashion domain and extend a products lifetime and lifecycle, we developed a solution that empowers users to quickly access information, simplify recycling and take-backs, gain a deeper understanding of specific products, and promote sustainability.

The use case itself comprises several smaller use cases and is based on the concept of *ProductGPT*, which we have extended by several additional features. Therefore, our use case encompasses five essential and well thought out features: *Decentralised Take-Backs*, *Recommerce*, *Detailed Product Information*, *Customer Reviews*, and a *Rewarding System*.

To specify, visualize, and validate our use case, we have also implemented a digital prototype as a *Web Application*, illustrated in Figure 1. The following section will therefore shortly present the technological aspects and implementation details of the prototype, followed by a detailed description of the five key features of our use case, all of which were implemented in the digital prototype.

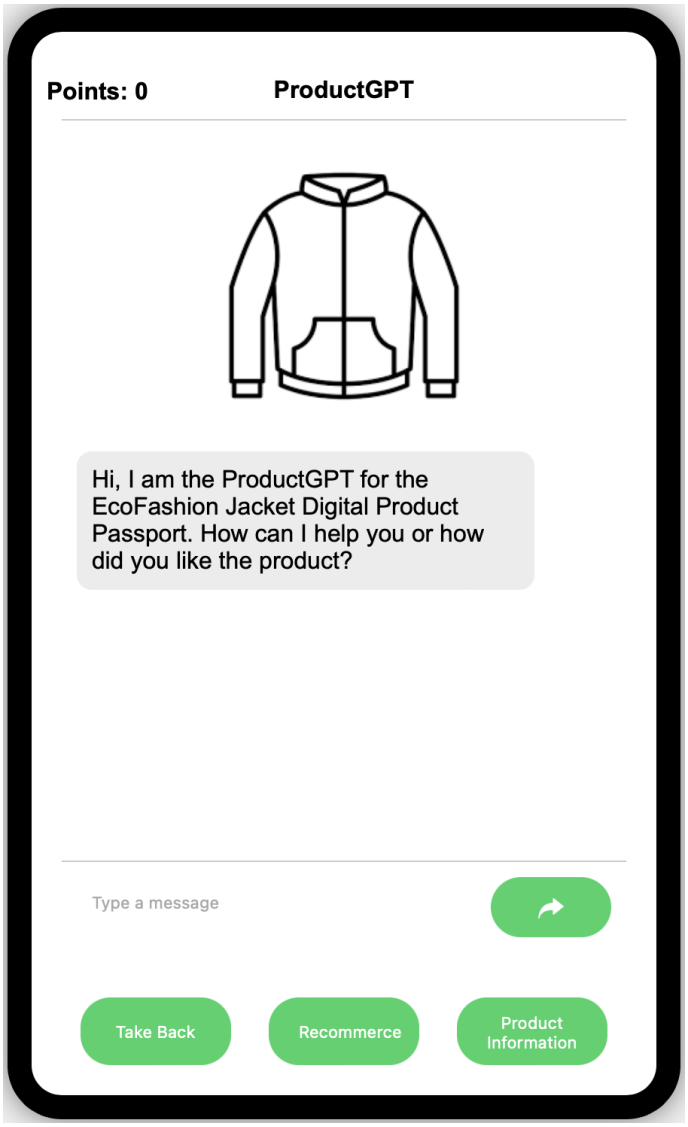

Figure 1: Digital prototype of our Developed Use Case

3.2.1 Technological Aspects and Implementation

ProductGPT enables users to chat and interact with a product through its DPP. To also realize this in the prototype, we implemented a digital prototype by leveraging two different AI models from *Huggingface* [5] specialized in natural language processing and machine learning.

The first model, *'YAKE!'* [6], is an automatic keyword extraction method that selects the most relevant keywords of a text, allowing us discern users' primary concerns. Thereby, we specifically target the two most significant keywords in each text. To further analyze and classify the sentiment of users' concerns, we employed the *'sentiment-analysis'* [7] model, which categorizes a given text into three sentiment labels based on the embedded emotions and opinions: positive, negative, or neutral.

For the implementation of the digital prototype, a *'Visual Studio Code'* environment with *Python* version 3.8.5 was used. To integrate the AI models into a web application, we utilized *'Flask'*, a web framework for *Python* [8]. *Flask* allows to simply start a local web server. This allowed us to connect the *Python* components and the *Web Application*, which was based on *JavaScript* and *HTML*.

3.2.2 Features

To conceptualize the structure and functionalities of our solution, we first created a process flow chart of the main features, as illustrated in Figure 2. The following section provides a detailed explanation of these five essential features, outlining their individual roles and contributions to the overall solution. Figures 4 to 7 in the appendix B *Functionality of the Prototype* illustrate the respective functionality of the prototype for each of these features.

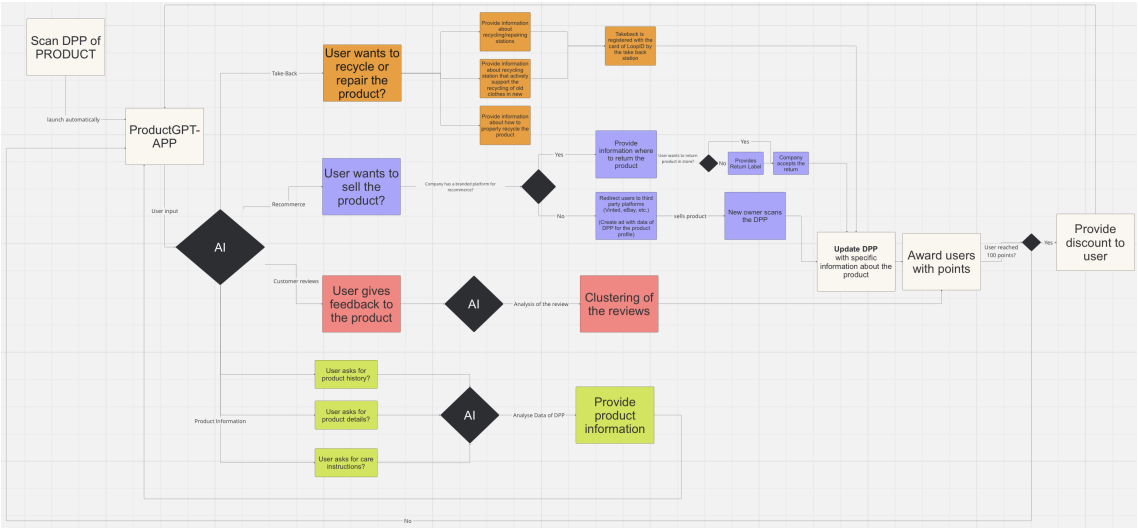

Figure 2: Process Flow Chart of the Developed Features of the Use Case

After scanning the QR code or NFC Chip of a fashion product, the *ProductGPT* app launches automatically, allowing users to chat with the product by using the two AI models and the DPP of the product. Thereby, the user is given numerous possibilities:

[5] `https://huggingface.co`
[6] `http://yake.inesctec.pt`
[7] `https://huggingface.co/blog/sentiment-analysis-python`
[8] `https://pythonbasics.org/what-is-flask-python/`

Decentralised Take-Backs If the user wants to recycle or repair their product, ProductGPT provides information on take-back stations for recycling and repairing. Since only 1% of used clothes are currently recycled into new clothes due to new, only now emerging technologies [16], *ProductGPT* additionally offers details on specialized take-back stations supporting these technologies. Finally, it also provides detailed information on proper recycling of a product, addressing the lack of consumer awareness of the opportunities to recycle clothing, as highlighted in research [25, 27, 28]. This feature supports the circular economy by extending product lifetimes and lifecycles through proper recycling and repairing, thereby also reducing resource consumption.

Recommerce If the user wants to sell the product, *ProductGPT* facilitates peer-to-peer recommerce through a branded platform or a company program. Thereby, users are given the opportunity to return the product in store or send it back to the company. When there is no recommerce offer by the product's company itself, *ProductGPT* also provides recommerce through third parties like *'Vinted'* [9] or *'eBay'* [10]. This feature supports the circular economy by extending product lifetimes.

Detailed Product Information Based on the DPP, *ProductGPT* offers detailed product information on specific details, the history, as well as care instructions. Thereby, *ProductGPT* addresses the frequent lack of consumer confidence in their ability to care for clothing correctly, as outlined in the study of Langley et al. [26]. This increases transparency and tackles the problem of *'no label'*, meaning that products cannot be recycled correctly due to a lack of information about their materials [29]. The DPP in *ProductGPT* counters this issue by providing all the necessary information, thereby extending product lifetimes and lifecycles.

Customer Reviews Our use case also integrates customer reviews as an additional feature of *ProductGPT*. Thereby, the two integrated AI models evaluate customer reviews and interactions, classifying and clustering them to provide feedback to companies. The AI models assess the respective aspect and associated sentiment of the review, thereby also providing an analysis of the customer reviews to the companies and helping them improve the product in the next manufacturing round. This not only extends product lifetimes but also increases customer satisfaction.

Rewarding System The features of *Decentralized Take-Backs*, *Recommerce*, and *Customer Reviews* are always tracked and authorized by *ProductGPT* through registrations, acceptance and authentication. Once users successfully recycle, engage in recommerce, or provide customer reviews, the respective DPP of the product is updated. Users also receive reward points. When accumulating 100 points, they are also offered a discount by the product's company. Thereby, we want to engage users to use the app frequently and support our solution.

[9] `https://www.vinted.de`
[10] `https://www.ebay.de`

4 Business Model

To provide a comprehensive solution for enhancing sustainability in the fashion domain, we developed a business model of our use case of *ProductGPT*, detailed in the following section. An illustration of this model is also included in the appendix C *Business Model*, Figure 8.

The development and integration of *ProductGPT* and the proposed features form *LoopID's* core activities. This involves developing advanced AI technology, embedding it into customer systems, and promoting its adoption through marketing. Critical resources include a robust AI backend and a user-friendly frontend interface.

Our target audience includes consumers, manufacturers, as well as companies. In our use case, consumers benefit from extended product lifetimes and the ability to more easily repair and recycle their products. Additionally, *ProductGPT* enhances user experience by simplifying product reselling, offering informed maintenance, and providing transparency in product origins and lifecycle. This leads to improved brand recognition and the potential for premium pricing [25]. Furthermore, companies benefit from user feedback for continuous improvement, support in sustainability initiatives, a DPP, and an enhanced transparency and sustainability by implementing a DPP.

Our customer segment spans from fast fashion to sustainable fashion companies, focusing on those already committed to sustainability. Key partnerships with recommerce platforms, fashion brands, and recycling companies facilitate resale, embed sustainability, and ensure proper recycling processes.

Customers can be reached through presentations, workshops, partnerships, and networking events, which are essential for acquisition and retention. Relationships are maintained through dedicated contact persons.

Revenue streams come from implementation and maintenance fees, with potential partnerships with recommerce platforms. Costs predominantly include the development and maintenance of *ProductGPT* and the proposed features, AI service costs, marketing, and sales.

5 Validation and Results

To evaluate and validate our solution and gather individual opinions, we conducted an online survey with 51 participants. The online questionnaire is also included in the appendix D *Online Questionnaire*. *R*, a programming language for statistical data analysis, was used to process, evaluate and visualize the results from the online survey.

The evaluation of the online questionnaire revealed that participants' experiences with our prototype and proposed use case were generally very positive, as indicated by the overall positive feedback.

The key results of the online questionnaire are shown in Figure 3 and presented below, while the complete results can be found in the appendix E *Validation of the Online Questionnaire*, Figure 9. Thereby, participants rated several statements on a 5-point Likert scale: (1) *Strongly Disagree*, (2) *Disagree*, (3) *Neutral*, (4) *Agree*, and (5) *Strongly Agree*.

One significant challenge in extending product lifetimes in the fashion domain is ensuring the profitability of our use case for companies, particularly when fewer products are sold over time due to recycling, repairing or recommerce. This profitability was confirmed by our study. Results showed that participants were willing to pay a premium price for longer-lasting fashion products (86%) (median $\tilde{x} = 4$, $min = 2$, $max = 5$),

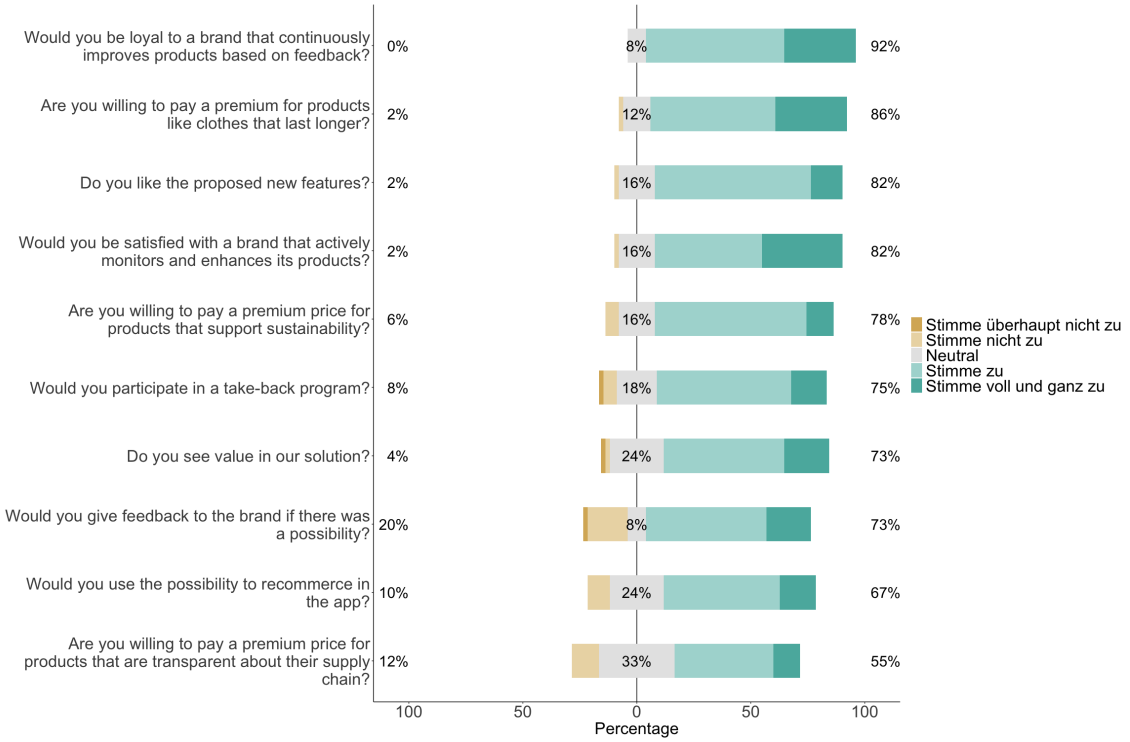

Figure 3: Likert Plot of the Key Results of the Online Questionnaire

sustainable products (78%) ($\tilde{x} = 4$, $min = 2$, $max = 5$), and products with transparent supply chains (55%) ($\tilde{x} = 4$, $min = 2$, $max = 5$).

Moreover, the additional features of our use case also received positive feedback. 75% of participants would participate in take-back programs ($\tilde{x} = 4$, $min = 1$, $max = 5$), 73% would provide feedback to company ($\tilde{x} = 4$, $min = 1$, $max = 5$), and 67% would use the possibility to recommerce ($\tilde{x} = 4$, $min = 2$, $max = 5$).

The study further confirmed that participants would be loyal (92%) ($\tilde{x} = 4$, $min = 3$, $max = 5$) and satisfied (82%) ($\tilde{x} = 4$, $min = 2$, $max = 5$) with a company that continuously monitors and improves products based on feedback, which is enabled through the customer reviews in our use case.

Furthermore, 82% of participants liked our proposed *ProductGPT* features ($\tilde{x} = 4$, $min = 2$, $max = 5$). As for our solution as a contributor to reducing fashion waste, the circularity, and sustainability of fashion products, 73% of survey participants recognized value in our solution ($\tilde{x} = 4$, $min = 1$, $max = 5$).

Finally, for a detailed evaluation of the usability of our prototype, we used the original *System Usability Scale* (SUS) [30]. The resulting SUS score is represented by a single number between 0 (minimum) and 100 (maximum), indicating the system's usability. Thereby, our prototype achieved an average score of 70.34 (standard deviation $\sigma = 7.67$, $min = 45$, $max = 80$).

6 Conclusion and Outlook

Recognizing the potential of our use case to extend product lifetimes and promote the circular economy, combined with the positive feedback and results from our survey, underscores the significant promise of our solution in the fashion domain. However, it is essential to note that our product is currently in prototype stage, necessitating ongoing improvements and future steps.

Regarding the implementation, the AI models can be further enhanced to facilitate more extensive interactions. Moreover, the next steps include an initial focus on the fashion domain and the development of our proposed features, which aim to introduce *ProductGPT* effectively to end-users while creating revenue for the companies.

Given the time constraints during the workshop week, our validation methods were limited in representing the broader population. Conducting a comprehensive survey that is representative as further validation strategies is crucial to understand the willingness to engage with *ProductGPT* and support the circular economy. This data will be pivotal in pitching the product to potential customers.

In conclusion with the sustainable context, while our prototype servers as a positive indicator of sustainability, it is designed to empower users to make informed, sustainable decisions. Therefore, our implementation inherently promotes sustainability.

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Appendix

A Interviews

Interviews – all translated in english

1. **Nina Rein** – phone interview

1. What financial advantages and challenges arise for your company from the fact that your products are long-lasting?

- there are no financial advantages at all

- products that are too expensive are also impossible to sell to buyers because you lose customers

- automatic cost increases due to material, fabric

2. Why is sustainability in the fashion sector so important to you?

- Flooding in Bavaria will become a daily occurrence and profit from deforestation should not be because of your products

- you want to stand behind your product and not be a reason or have any involvement in this disaster

3. Who are your customers and how do you deal with competition? -Company is based on the emotional values and awareness of the company and the customers, who are the same

- these same values mean there is no corresponding competition, customers remain loyal until there are no cost increases

- Customers who prefer classic style and customers who still value clothes

4. What challenges were there when founding the company?

- these challenges are still present, not just when it was founded

- small companies have no chance against large corporations

- minimum quantities prepare problems, financial and resource-related

- fabric suppliers prefer large orders

- "Everything is time, everything is money"

5. Are there any subject areas in which artificial intelligence could take on a task?

- AI is already being used

- "I only have 24 hours a day and few employees"

- ChatGPT and Canva for designs

2. **Nikin** – answered email

1. What financial benefits and challenges does making your products durable bring to your company?

Durable products bring us several financial benefits. On the one hand, they create trust and satisfaction among our customers, which leads to long-term customer loyalty and repeat purchases. On the other hand, they help us position our brand as sustainable and high-quality, which sets us apart from the competition and enables higher pricing strategies. The challenge, however, is that the production costs for durable and sustainable materials are often higher and, to be frank, there are also fewer repeat purchases, as if the quality were a bit worse (but as a sustainable brand, we want the best possible quality for a fair price that a large part of the population can afford).

2. Why is sustainability in fashion so important to you?

Sustainability is very important to us at NIKIN, as the fashion industry has a significant impact on the environment and is actually one of the dirtiest industries and is responsible for more CO2 emissions than flying etc. Our goal is also to make a positive contribution by using sustainable materials, planting a tree for every product sold and launching more circular products in the future. This helps to reduce the ecological footprint of the fashion industry while raising consumer awareness of sustainable practices.

3. Who are your customers and how do they deal with competition?

Our customers are mainly environmentally conscious consumers who value sustainable and ethically produced fashion. They are mostly between the ages of 25-34 and value transparency and authenticity. They care a lot about the environment and especially nature, without wanting to do everything in every area of life. Our customers are therefore not “hardcore eco-freaks”.

4. What challenges did you face when founding the company?

One of the biggest challenges when founding NIKIN was to build awareness for our brand. In addition, it was not always easy to find sustainable supply chains and production partners who work to high standards, made in Europe and with good prices. Finding the balance between economic efficiency/profit and the other areas of sustainability (ecology & social) was and is a continuous challenge.

5. Are there areas in which artificial intelligence could or already is taking on a task?

AI could be useful in several areas of our company, for example in marketing to create personalized recommendations for customers, or in logistics to manage inventory more efficiently. At the moment we mainly use ChatGPT for summaries, brainstorming, evaluating Excel files, etc.

3. **Ucon Acrobatics** – interview not conducted by us, but send by email from Ucon Acrobatics to use the information

Interview with the founders Jochen Smuda (Marketing and Sales) and Martin Fussenegger (Design and Production)

Ucon Acrobatics is one of the first companies in the world to commit to producing bags and backpacks that consist largely of textile waste. But how did this decision come about and how much work is involved?

Jochen Smuda: We are aware that every form of production has a negative impact on our planet. That is why we have developed a certain ambition to always focus on the most sustainable production methods. Because what was called 'sustainable' yesterday is no longer so today. We are also constantly learning and have finally become more and more involved with the circular economy. No one can close their eyes to the huge amounts of old clothing that are generated every day. Every second, somewhere on earth, a truckload of textiles is dumped in landfills or burned. We need viable recycling concepts for textiles and quickly. So we thought, why wait for the big corporations - we should be able to do it as a small label!

Martin Fussenegger: I have been fascinated by the concept of the circular economy since I was young. So I did some research and read thousands of pages of scientific papers and did intensive research. It only took a year from the concept to the conversion of the entire supply chain. We are still constantly optimizing the processes and materials together with our suppliers - from the sewing factories to the recycling company. Until recently, the latter were recycling old clothes for us in pilot plants, which was quite costly at first. But we want to be pioneers of the circular economy in the area of bags and backpacks, so that other brands will soon follow our example.

The use of recycled PET bottles is increasingly coming under criticism. The decision to use textile waste instead of recycled PET bottles marks a significant step towards sustainability for Ucon Acrobatics. A new type of chemical recycling process is used for this. But what exactly makes the decisive difference?

Jochen: The food industry has now also started to recycle its plastic bottles as the price has dropped. And that's a good thing, because so-called mechanical recycling from bottle to bottle works well as a circular process. But once the plastic bottles have been processed into textiles, it is difficult to recycle the polyester again. The textile industry needs to build its own functioning cycle instead of buying up the bottles from the food industry because it is cheaper. Otherwise, they have to produce new bottles again.

Martin: One process that could fundamentally change the textile industry is chemical recycling. It is one of the most sustainable and scalable levers there is. Once the technology is mature, an estimated 70% of textile waste could be fed into this fiber-to-fiber recycling. Synthetic fibers such as polyester are broken down into their original chemical building blocks and then used to produce new synthetic fibers. The chemical recycling process we use is based on glycolysis. The higher the purity of the material, the less energy is required for chemical recycling. Our goal is therefore to manufacture products with almost 100% recycled mono-materials from our own industry, which can then be recycled again and again. This creates a cycle.

The textile industry is faced with the challenge of solving its massive waste problem. As a small company, it is difficult to take a pioneering role and at the same time remain economically viable. How can you as a small company overcome this challenge?

Jochen: Small companies have the advantage of agility. If we think a measure makes sense, we implement it as quickly as possible. There is no need for months of meetings and feasibility studies. In this case, however, we made the decisions based on ecological, not financial, considerations. Of course, we had to take certain financial risks. But we did not let ourselves be dissuaded when the material prices exceeded four times our usual level.

Martin: For many of the big brands, this is probably an automatic exclusion criterion; perhaps the reason why the doors of the recycling companies were so wide open for us. We took advantage of this to visit all of these new recycling companies, get to know the people behind them personally and have the processes explained to us in detail. At the same time, we put textile recycling on the agenda of lower-level partners in the supply chain and established business relationships between manufacturers so that others can follow this path more easily.

The aim of Ucon Acrobatics is to gradually convert the entire production from 2024 onwards in order to make all products recyclable and to manufacture them with the highest possible proportion of recycled textiles. What specific measures and challenges are associated with this ambitious goal?

Martin: We didn't make it easy for ourselves and simply started with the biggest challenge. Our best-selling series is a type of synthetic leather made of PU. In a development period of over two years, we managed to make the material of this Lotus Infinity series 100x more abrasion-resistant, among other things, and thus drastically extend its service life. At the same time, half of it is made of recycled textiles. For later recyclability, however, you have to look at the whole product and not stop at the main material. We have replaced all PP sheets with PET hard felt sheets made from recycled textile waste. The PE foams have been replaced with soft PET felt sheets. These products have been on the market since autumn 2023. It works so well that we are currently expanding the process to all products in the range.

The result is impressive. To produce a Hajo Medium Backpack from the Phantom series, we recycle 1kg of textile waste. The proportion of textile waste in the entire backpack is almost 90%. If you cut off the metal parts, the product can already be chemically recycled today. We want to start a transparency campaign on our website soon. The most important data for each individual product will be published there, not just in relation to individual materials, but also in relation to the total weight.

One of the biggest challenges for us as a small company, however, is the switch to the spin-dyeing process, which requires quite high minimum quantities. The process reduces water consumption by up to -90%, chemical consumption by up to -80%, energy consumption and CO_2e emissions by up to -50%. Despite this gigantic ecological advantage, only 3.5% of textiles were spin-dyed in 2021. With the Hajo Backpack mentioned above, we achieve a process share of over 80% of all dyed textiles.

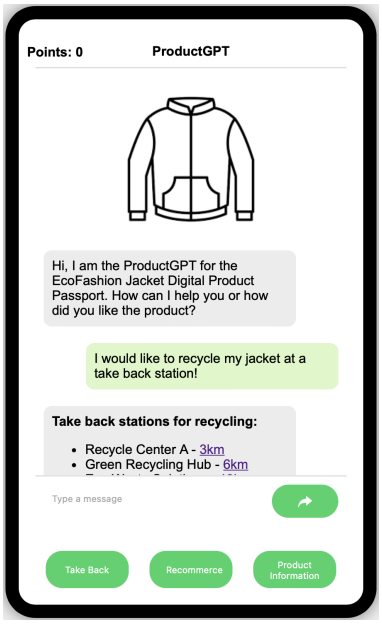
The fashion industry is facing an urgent need to focus more on sustainability and the circular economy. How does Ucon Acrobatics hope to inspire other companies in the industry to pursue similar innovative approaches through its pioneering role and what message do you want to convey to the industry and consumers?

Jochen: Unfortunately, we are experiencing a regression in terms of sustainability. The market is flooded with ultra-fast fashion companies that are increasingly producing inferior products. At the same time, customers are using the products for less and less time. Numerous companies engage in greenwashing to give the impression that their production is sustainable or that the products are even emission-neutral.

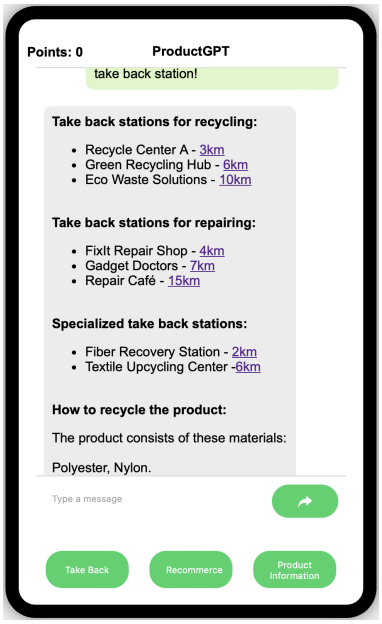
Companies have to start really going where it gets very unpleasant - when it comes to margins and resources. Acting sustainably as a company is more expensive and time-consuming, if you're honest about it. But even as a small company with less than ten employees, we were able to manage it. Of course, this slowed us down on other issues, but if we can do it, others can do it too.

In the fashion industry, we finally have to go a step further and become circular-oriented in order to prevent the market from being flooded with waste. It is important that customers carefully check which companies and products they are supporting with their purchases. We hope for a change in the mindset of companies and consumers.

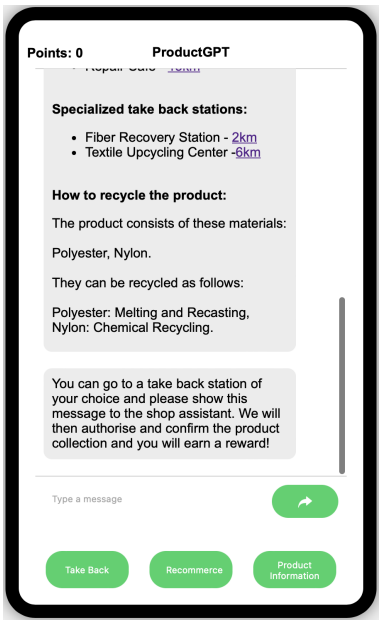
B Functionality of the Prototype



(a) Decentralised Take-Back 1

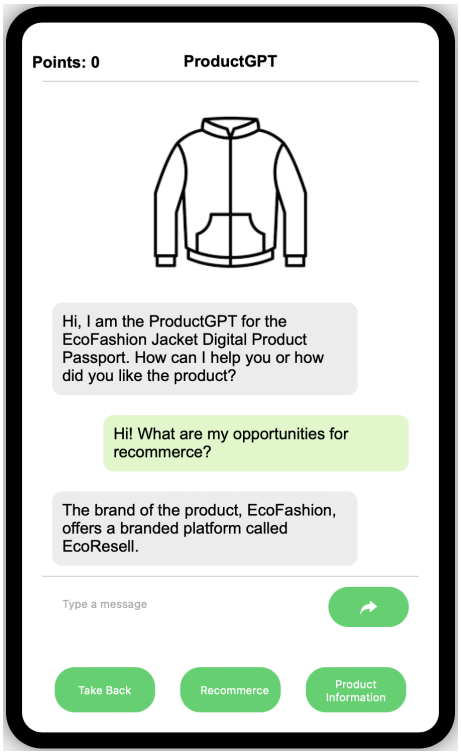


(b) Decentralised Take-Back 2

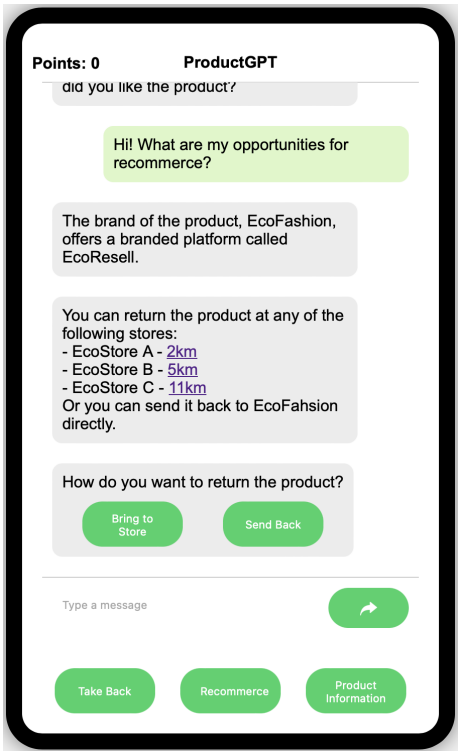


(c) Decentralised Take-Back 3

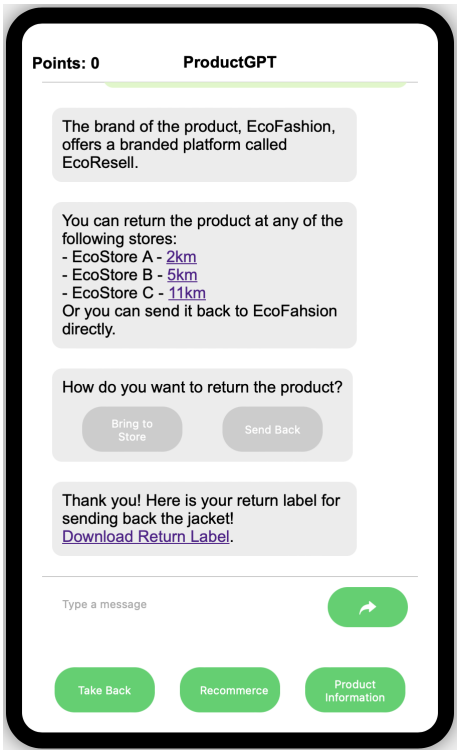
Figure 4: Prototype demonstrating the Functionality of the *Decentralised Take-Back* Feature



(a) Recommerce 1

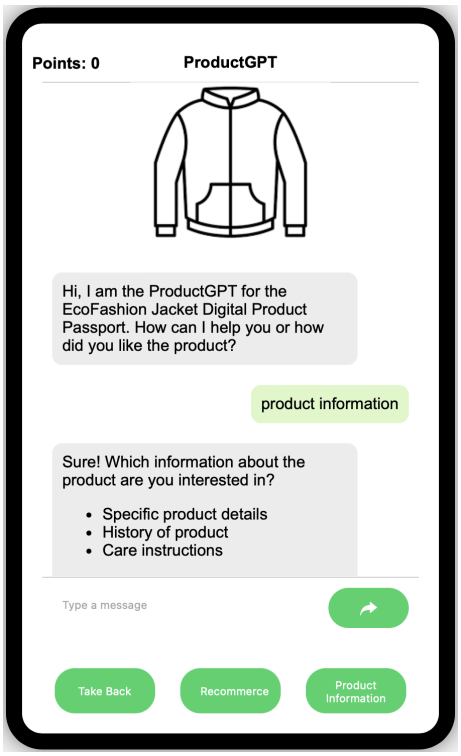


(b) Recommerce 2

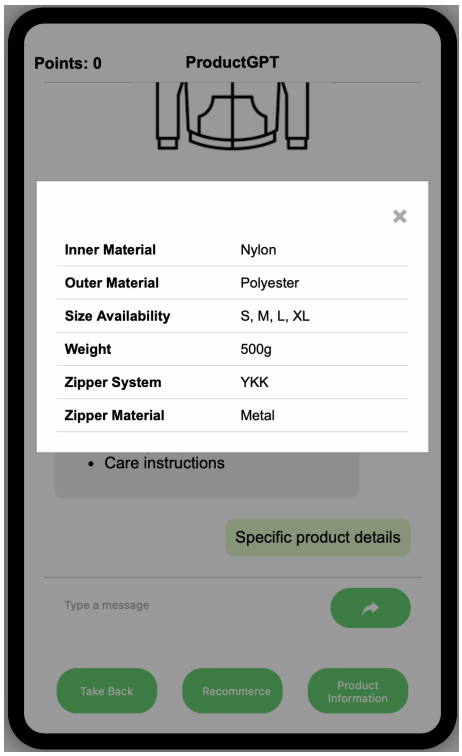


(c) Recommerce 3

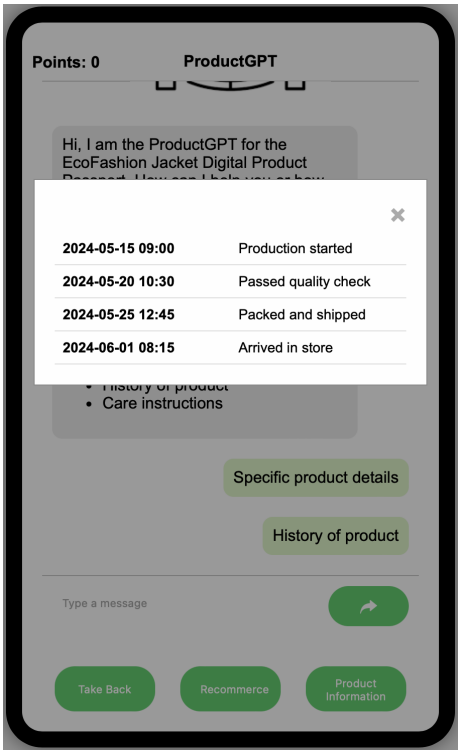
Figure 5: Prototype demonstrating the Functionality of the *Recommerce* Feature



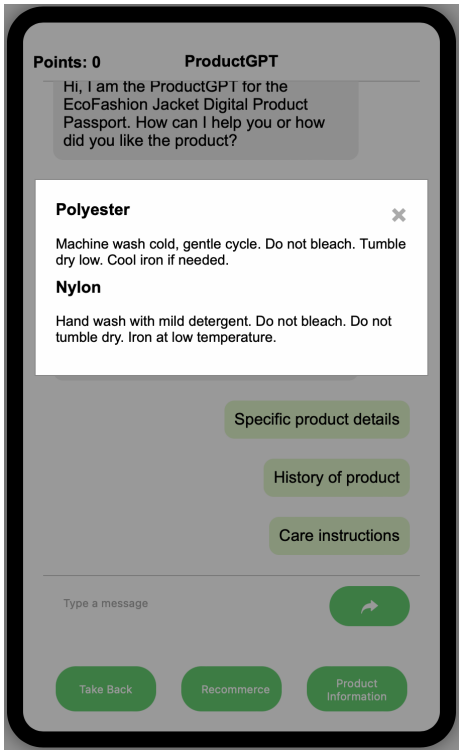
(a) Detailed Product Information 1



(b) Detailed Product Information 2

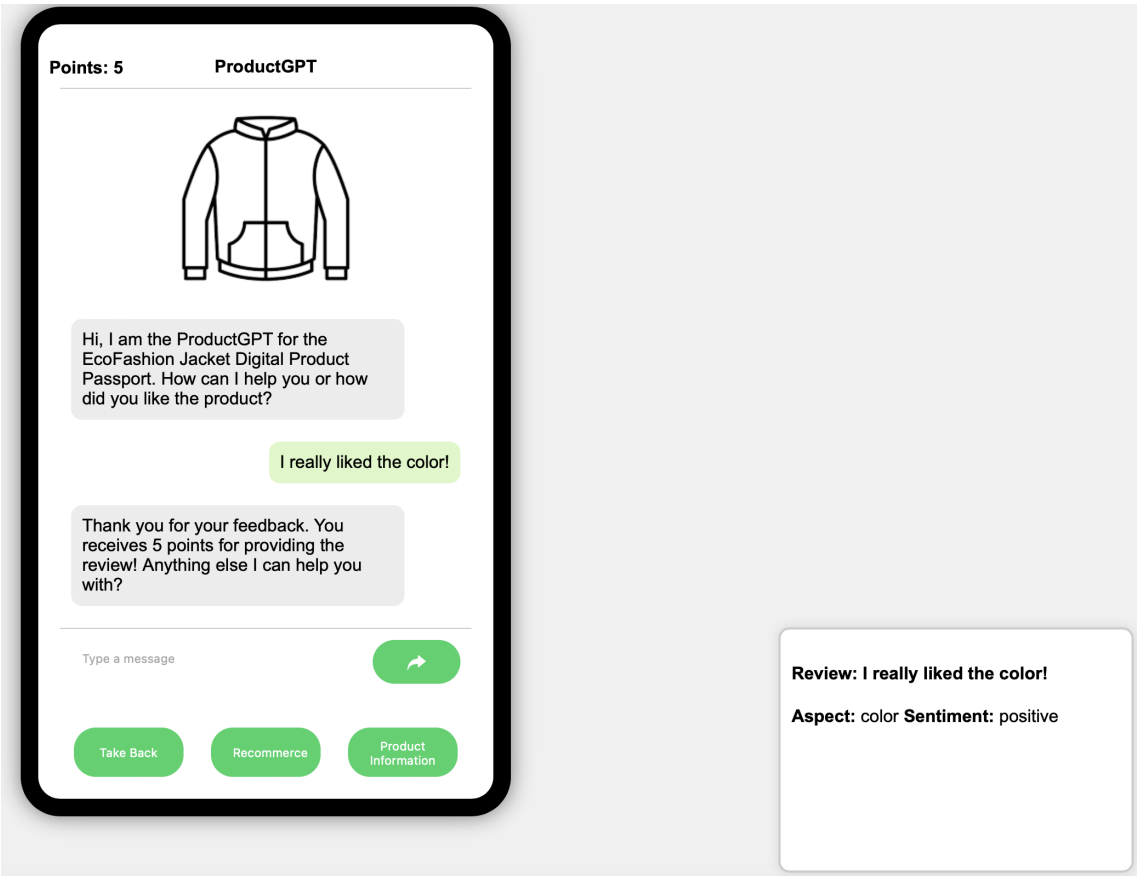


(c) Detailed Product Information 3

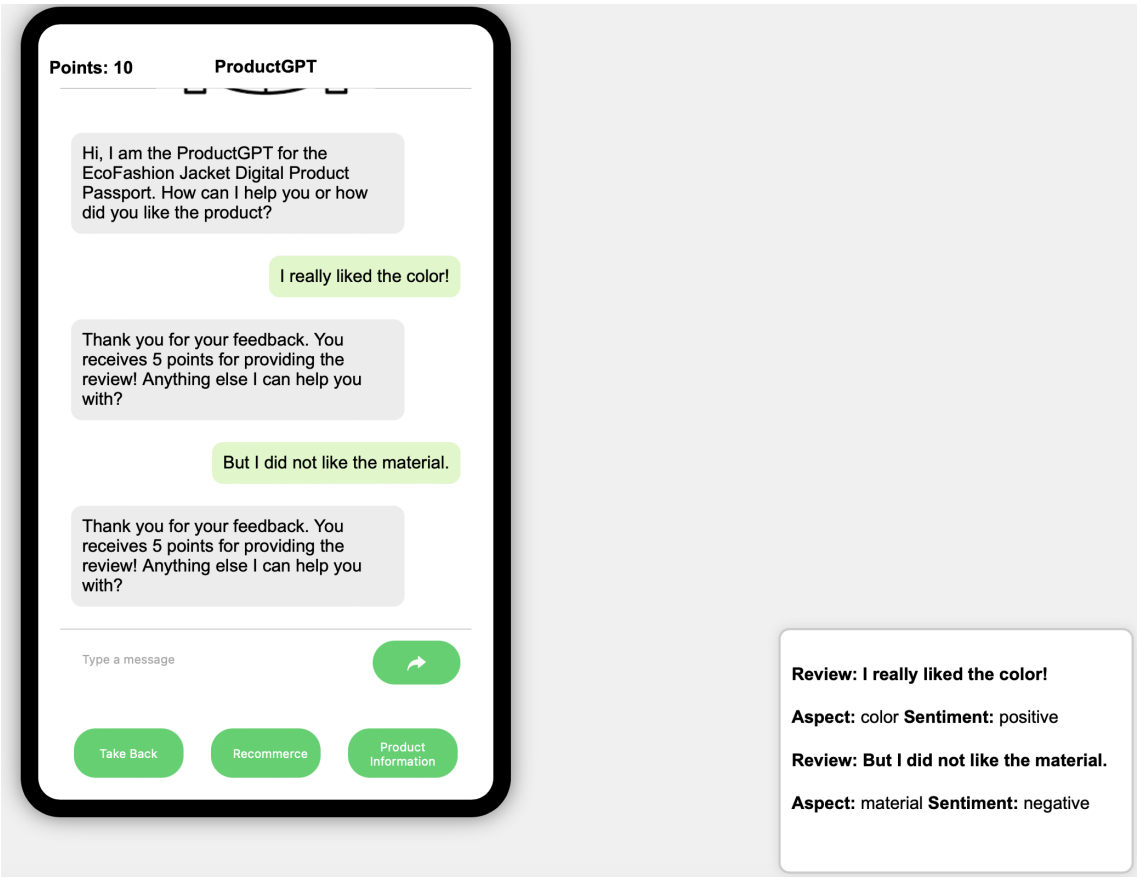


(d) Detailed Product Information 4

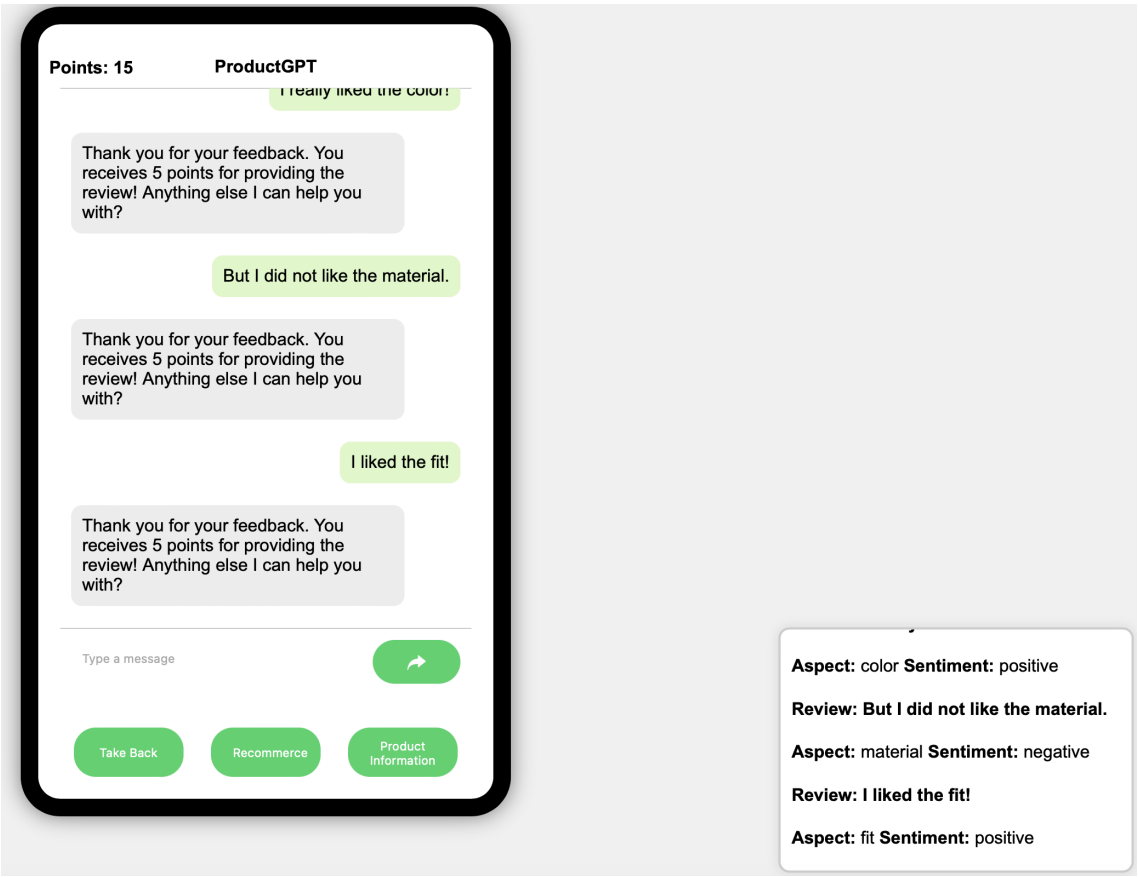
Figure 6: Prototype demonstrating the Functionality of the *Detailed Product Information* Feature



(a) Customer Review 1



(b) Customer Review 2



(c) Customer Review 3

Figure 7: Prototype demonstrating the Functionality of the *Customer Review* Feature including the Aspect and Sentiment Analysis of the Review by the AI Models (bottom right corner) as well as the *Rewarding System* Feature (top left corner of the Screen)

C Business Model

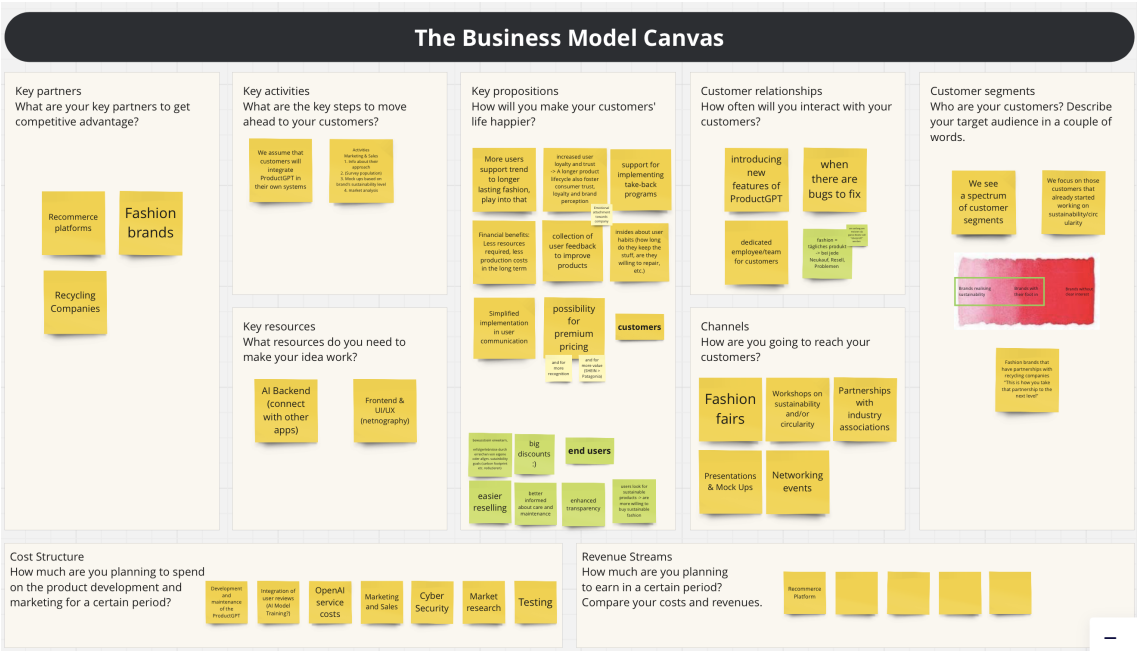


Figure 8: Business Model of the Developed Use Case

D Online Questionnaire

Seite 01

FR60

Thank you for participating in our study on our ProductGPT prototype as part of our SustAInability seminar!

Before we provide you with questions, we would first like to briefly introduce you to our prototype!

Waste production has increased significantly and is one of the mein problems our society is facing today. Every year, the global economy generates more than 2 billion tons of solid waste. Moreover, products often become obsolete or are disposed of before reaching the actual end of their lives. Therefore, adequate waste management is more critical than ever.

The circular economy has come increasingly into focus, allowing materials to be used repeatedly by ensuring that the materials of a product are kept within the economy for as long as possible through recycling when a product reaches the end of its life. One of the main aspects of circular economy is the extension of the lifecycle of products.

To extend the lifecycles of products in the fashion domain, we conceptualised a digital prototype in the fashion domain.

To get a better understand of the prototype, a demonstration video is provided below for you, but we will also briefly explain the main features of our prototype:

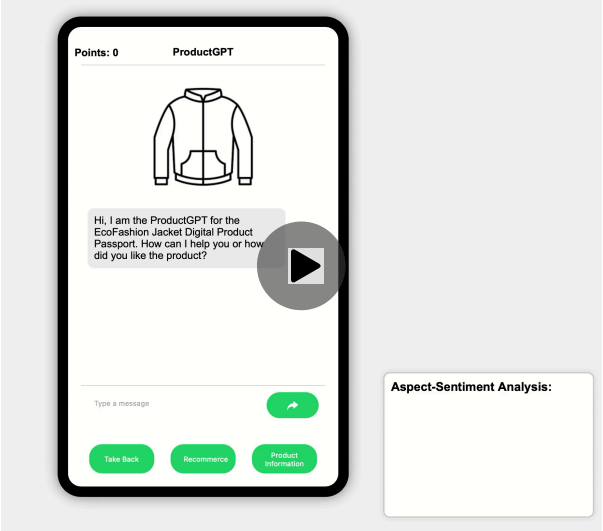
Decentralised Take Backs: ProductGPT povides information about recycling and repairing stations, specialised take back station which use old clothing to produce textile fibres for new clothing as well as information on how to properly recycle the product. The take back is then registered at the tack back station and you are rewarded with 5 points.

Recommerce: Regarding recommerce, ProductGPT provides information where to recommerce the product, either by the company of the product itself or by third parties. When the recommerce is authorised, you will also receive 5 points.

Customer reviews: You can give us feedback of the product - with every provided customer review you also receive 5 points!

Product information: ProdutGPT provides details about the product.

Rewarding system: When you reach 100 points, you are offered a discount by the company of the product!


Points: 0
ProductGPT
Hi, I am the ProductGPT for the EcoFashion Jacket Digital Product Passport. How can I help you or how did you like the product?
Type a message
Take Back
Recommerce
Product Information
Aspect-Sentiment Analysis:

Seite 02

General Questions

FR52

FR59

1. How much money are you willing to spend for a jacket?

- ○ 20-50 Euro
- ○ 50-100 Euro
- ○ 100-200 Euro
- ○ 200-300 Euro
- ○ 300-500 Euro
- ○ >500 Euro

FR47

2. To what extent do the following statements apply to you?

	stimme überhaupt nicht zu	stimme nicht zu	Neutral	stimme zu	stimme voll und ganz zu
Are you willing to pay a premium for products like clothes that last longer?	○	○	○	○	○
Are you willing to pay a premium price for products that are transparent about their supply chain?	○	○	○	○	○
Are you willing to pay a premium price for products that support sustainability?	○	○	○	○	○
How important is sustainability for you?	○	○	○	○	○

Seite 03

Questions on Take Back

FR53

FR48

3. To what extent do the following statements apply to you?

	stimme überhaupt nicht zu	stimme nicht zu	Neutral	stimme zu	stimme voll und ganz zu
Would you participate in a take-back program?	○	○	○	○	○
How valuable do you find take-back programs?	○	○	○	○	○

Seite 04

Questions on Recommerce

FR55

FR58

4. To what extent do the following statements apply to you?

	stimme überhaupt nicht zu	stimme nicht zu	Neutral	stimme zu	stimme voll und ganz zu
Would you use the possibility to recommerce in the app?	○	○	○	○	○
How valuable do you find recommerce?	○	○	○	○	○
Would you recommerce in the app frequently?	○	○	○	○	○

Seite 05

Questions on Customer Reviews

FR54

FR49

5. To what extent do the following statements apply to you?

	stimme überhaupt nicht zu	stimme nicht zu	Neutral	stimme zu	stimme voll und ganz zu
Would you give feedback to the brand if there was a possibility?	○	○	○	○	○
Would you be loyal to a brand that continuously improves products based on feedback?	○	○	○	○	○
Would you be satisfied with a brand that actively monitors and enhances its products?	○	○	○	○	○

Seite 06

Questions on Usability

FR56

FR51

6. To what extent do the following statements apply to you?

	Stimme überhaupt nicht zu	Stimme nicht zu	Neutral	Stimme zu	Stimme voll und ganz zu
I think I would like to use the app frequently	○	○	○	○	○
I found the app unnecessarily complex	○	○	○	○	○
I found the app easy to use	○	○	○	○	○
I think I would need the help of a technically competent person to be able to use the app	○	○	○	○	○
I think the various functions in the app were well integrated	○	○	○	○	○
I think the app contained too many inconsistencies	○	○	○	○	○
I can imagine that most people learn how to use the app very quickly	○	○	○	○	○
I found the app very cumbersome to use	○	○	○	○	○
I felt safe using the app	○	○	○	○	○
I think I would have to learn a lot before I could start using the app	○	○	○	○	○

Seite 07

Final Questions

FR57

FR50

7. To what extent do the following statements apply to you?

	stimme überhaupt nicht zu	stimme nicht zu	Neutral	stimme zu	stimme voll und ganz zu
Would users use our solution, do you see value in our solution?	○	○	○	○	○
Do you like the proposed new features?	○	○	○	○	○
Would you engage with the system?	○	○	○	○	○
	○	○	○	○	○

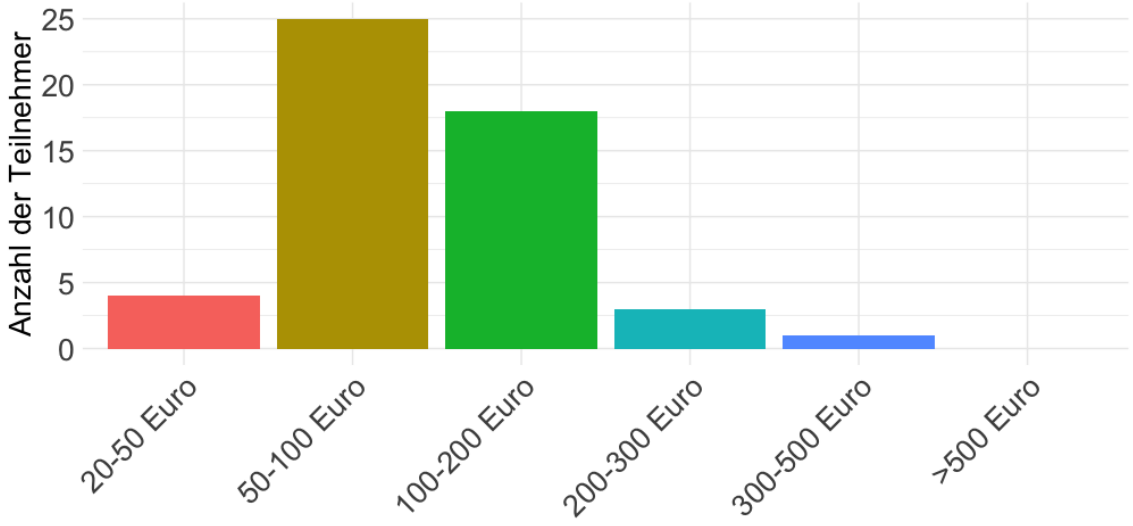
Letzte Seite

Vielen Dank für Ihre Teilnahme!

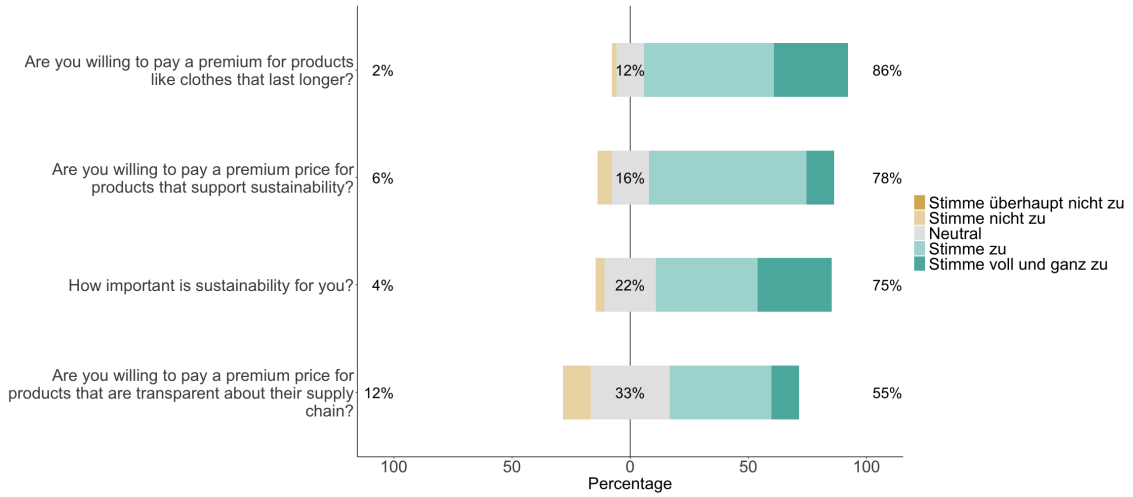
Wir möchten uns ganz herzlich für Ihre Mithilfe bedanken.

Ihre Antworten wurden gespeichert, Sie können das Browser-Fenster nun schließen.

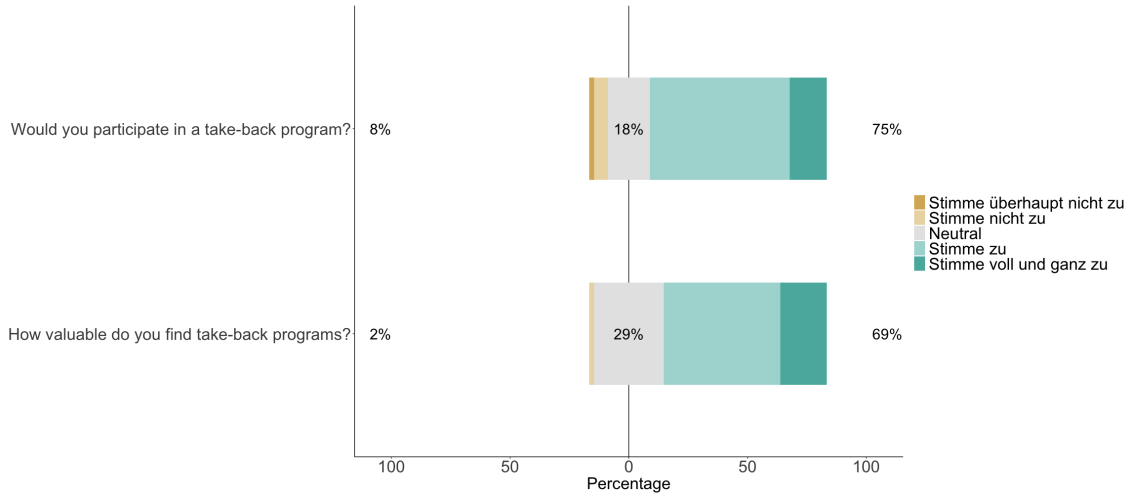
E Validation of the Online Questionnaire



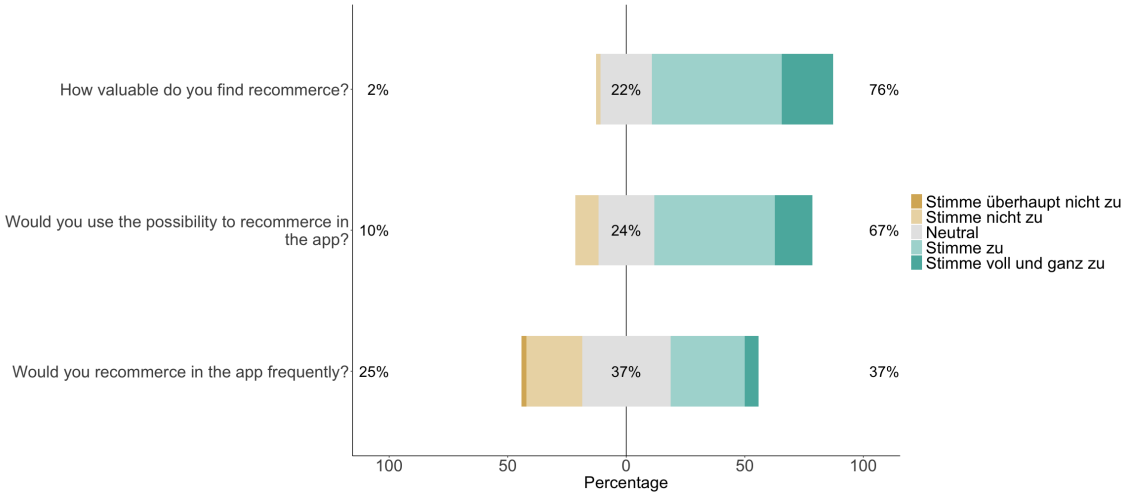
(a) Amount of Money Participants are willing to spend on a Jacket



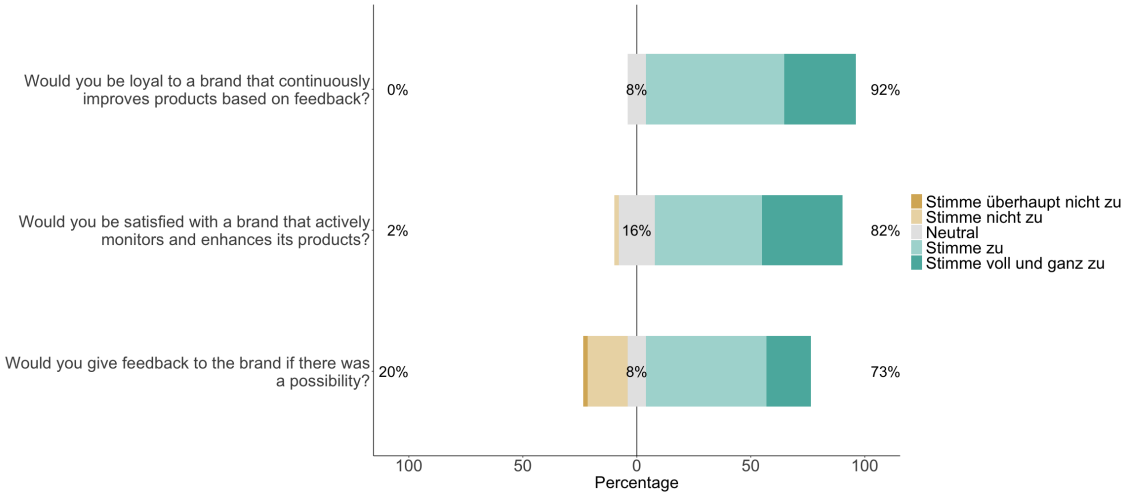
(b) Results on Participants' Willingness to pay a Premium Price for Longevity, Transparency, or Sustainability



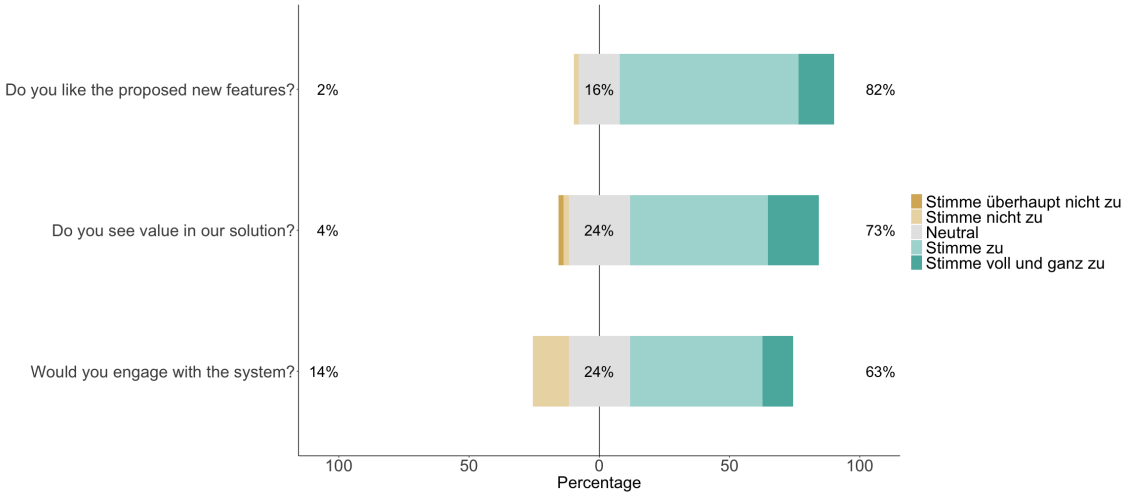
(c) Results of the *Decentralised Take-Back* Feature



(d) Results of the *Recommerce* Feature



(e) Results of the *Customer Review* Feature



(f) Results on Proposed Solution Features

Figure 9: Complete Analysis of the Results of the Online Questionnaire