




Towards an Eco-Gamification Platform to Engage Consumers in the Textile & Clothing Circular Economy

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Abstract: Nowadays people are buying too many clothes. This results in the overexploitation of the Earth's natural resources and an increase in waste that is not sustainable. It is necessary to consume fewer new resources, and alternatively reuse more, repair if necessary, share and donate more, and at the end of the garment life it is necessary to transform it to be used as raw material in the creation of new products and in this way contribute to the circular economy. This article proposes the creation of a gamified platform that engages consumers, brands and other participants in more sustainable practices at the same time that helps consumers to manage their clothing closet. It also allows consumers to manage other closets, such as their children's closet or their home textiles. The main goal is to encourage consumers to adopt more sustainable practices with regard to clothing and home textiles. The proposed platform allows to share and donate clothes through the creation of sharing/donation groups. The main objective is to contribute to the transition of the textile and clothing sector towards the circular economy, making it a more sustainable sector.

1 INTRODUCTION


Today's society, especially in developed countries, is too consumerist. This excessive consumption is leading to the depletion of the planet's natural resources and a huge increase in waste with harmful effects on soil, water and air. This trend must be reversed. It is necessary to reduce the consumption of new resources, replacing them with recycled materials, and prolonging the life of products in use.


The European Union, aware of the problem, has created directives for the management of textile waste and the reintroduction of fibers into the textile industry's value chain, encouraging the circular economy (Chioatto and Sospiro, 2023)^{1.c} Moreover, the European Union has identified the textile and clothing sector as a priority sector to move towards the circular economy (Vercalsteren et al., 2019).


The circular economy is seen as one of the most promising strategies to reduce the environmental impact of the textile industry (Gillabel et al., 2021). For

the circular economy to become a reality, it is necessary the participation and commitment of everyone involved in the value chain: governments, clothing designers, manufacturers, distributors, and consumers (Alves et al., 2023; Cruz and Rosado da Cruz, 2023; Vercalsteren et al., 2019). In fact, the end consumer plays a very important role in the circular economy. End consumers' decisions can lead them to purchase products with a lower environmental impact, implement a set of good environmentally friendly practices that extend the useful life of products in use, and influence other participants in the value chain through their good choices, among other results (Cruz and Rosado da Cruz, 2023).

Examples of the environmentally friendly practices that consumers can adopt are buying less and prolonging the life of clothes, by using a piece of clothing more often, making repairs, sharing, donating, renting or selling and buying second-hand clothes. Also, when a garment is no longer wearable, it can be sent for recycling so that it can be transformed into raw materials again, closing the CE loop (Gillabel et al., 2021; Cruz and Rosado da Cruz, 2023; Vercalsteren et al., 2019). Consumers can also choose to buy more environmentally friendly, or socially fair, clothes. To achieve this, consumers have to trust brands and this implies that brands implement trace-

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¹<https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L0851>

ability and transparency throughout the value chain. The use of a Digital Product Passport, with a sustainability index label that is easy to understand by all consumers, containing a classification and/or summary information of the social and environmental impact of clothing production, is essential to empower consumers for good/sustainable decisions and practices (Alves et al., 2022; Alves et al., 2024; Williams et al., 2023).

This article focuses on the end consumer. The goal is to encourage the end consumer to adopt more sustainable practices and, for that, we are proposing the creation and implementation of a gamified platform.

Gamification is a term that consists of applying certain fun and engaging elements, which are usually found in games, to a non-game context (Deterding et al., 2011). The concept of gamification comes from the gaming industry due to its ability to bring entertainment and positive experiences to human beings (Deterding, 2015). As conclude in (Cruz and Rosado da Cruz, 2023) gamification is a strategy that can effectively be used to challenge and involve citizens in the context of the circular economy and sustainability.

“Eco-gamification” or “green gamification” is a concept specifically aimed at encouraging more environmentally friendly behaviors. Basically, “Eco-gamification” consists in applying gamification elements with the aim of rewarding the user/consumer when they perform good environmental actions. “Eco-gamification” makes the user/consumer participation in the CE more fun and rewarding (Md Nor and Azhar, 2017). “Eco-games” promote environmentally sustainable behaviors by challenging the players to perform real-life tasks that contribute to reducing the environmental impact on the planet (Md Nor and Azhar, 2017).

In this article we are proposing the creation of a platform that uses gamification elements to involve the consumer in a set of more sustainable and environmentally friendly practices with regard to clothing/home textiles. At the same time, the proposed platform helps the consumer to manage not only their clothes closet, but also allows them to manage other closets, such as those of their children or their home (home textiles). The proposed platform also allows to share and donate clothes through the creation of sharing/donation groups.

This project emerged as a continuation of the project presented in (Alves et al., 2024) where the need to involve the consumer in the circular economy emerged in order to close the CE loop.

The rest of this article is structured as follows: Section 2 presents a background review of platforms

that try to encourage consumers to be more sustainable. Section 3 covers our proposed solution for the Eco-gamification platform. Finally, section 4 discusses results and presents conclusions and ideas for future work.

2 BACKGROUND REVIEW

A systematic literature review on digital strategies/tools for consumer engagement in sustainability and circular economy in the T&C value chain, has been previously carried out by some of this paper’s authors in the context of the same project (Cruz and Rosado da Cruz, 2023). The main objective of the project is to contribute to the transition of the textile and clothing sector towards the circular economy, making it a more sustainable sector.

2.1 Sustainability in Textile & Clothes

Numerous authors discuss sustainability and circular economy within the textile and clothing sector, and how the end consumer may be more involved in the process. In (Cruz and Rosado da Cruz, 2023) the authors have studied digital solutions for engaging end-consumers in that process, and have found examples of solutions for enticing end consumers to buy less, purchase environmentally and socially sustainable clothing, develop a pro-environmental consumer self-identity, engage in collaborative economy, repair/maintain clothes, either by themselves or through maintenance services’ companies, and giving consumers information about the traceability and sustainability of every garment or textile item, increasing the process transparency. Besides these consumer empowering solutions for engaging into CE and sustainable practices, other solutions were more organization-oriented and targeted at Brands’ marketing and educational activities towards sustainability and the Circular Economy.

Examples of solutions for some of these purposes are those presented in (Peña-Vinces et al., 2020; Shang and Wu, 2022), which aim to extend the life of clothes, by sharing, renting or donating clothes. The authors in (Peña-Vinces et al., 2020) propose a platform for selling children’s clothing. Children grow quickly, so clothes are only usable for a short period of time causing a lot of waste. Promoting clothes reuse, by reselling or donating them, is an important way of prolonging the useful lifetime of clothes.

In (Alves et al., 2024) the authors describe a project whose objective is to implement traceability of the value chain of the textile and clothing industry

in order to increase transparency in all supply chain. In this project, information is collected and stored to calculate the sustainability impact of a garment or home textile.

2.2 Eco-Gamification Platforms

There are several proposals for the creation of gamification platforms. Contributing to the eco-gamification discourse in the context of T&C, Kolstad et al., (2017) proposed a platform to automatically manage a clothes closet. In the proposed solution, all pieces of clothing are labeled with an RFID (Radio Frequency Identification) tag, thus allowing these pieces of clothing to be tracked (Kolstad et al., 2017). The same authors, in (Kolstad et al., 2018), propose an extension to this solution where a recommender system proposes clothes, which has not been used for a long time, for recycling.

In the context of the circular economy of the textile and clothing industry, in (Alves et al., 2023) the authors propose an gamified platform for the final consumers in order to register and track all activities related to clothes. The proposed platform is designed according to the GDH (Gameful Design Heuristics) framework heuristics.

In (Md Nor and Azhar, 2017) the authors propose and report a project that uses gamification techniques to encourage students at UiTM Perlis to behave more environmentally friendly and reduce their carbon emissions. Following similar ideas, Gustafsson et al., (2009) propose a game, developed in Sweden, to encourage teenagers and their families to reduce energy consumption at home (Gustafsson et al., 2009).

There are several platform proposals that use gamification strategies to encourage the use of public transport, as is the case of (Kazhamiakin et al., 2021) and (Cardoso et al., 2020). The platform proposed in (Kazhamiakin et al., 2021), in addition to encouraging citizens to use public transport, also helps transport service administrators in making decisions to better satisfy consumers. In (Cardoso et al., 2020), the authors propose a platform to encourage residents and tourists on the island of Madeira to use public transport.

Other authors have proposed gamified platforms to encourage consumers to recycle more, as is the case of (Hamberg et al., 2016) and (Briones et al., 2018). In (Hamberg et al., 2016), the authors present a game, developed in Sweden, to “engage” consumers in recycling. In (Briones et al., 2018), the authors present a study carried out in the city of Zaragoza, Spain, with the aim of evaluating a prototype of a mobile applica-

tion (eco-gamified), to encourage citizens to recycle more. The result was an increase in citizen participation by 32.2% and an increase in recycled waste by 17.2%.

3 THE PROPOSED PLATFORM

In this section, the main requirements for the proposed platform are presented, as well as the main models produced when designing the platform. The proposed platform aims to incentivize the user, i.e. the end-consumer, to engage into good practices towards CE in the T&C value chain, as identified in section 2.1.

3.1 Gamification Elements

The gamification elements have been selected according to the Gameful Design Heuristics, identified in (Alves et al., 2023). The article (Alves et al., 2023) has been published within the scope of the same project and three of authors are the same in both articles. The set of good practices that the consumer can execute may be grouped into three phases:

- Before buying, that is, when the consumer makes a decision about what to buy. The consumer can choose to buy more sustainable products (that is more environmentally friendly or more socially fair products); The consumer can choose to buy second hand; etc.
- During possession/use, that is, while the item is in the consumer’s possession, the consumer should act to extend the useful lifetime of the product, by reusing it as many times as possible; maintain the clothes, by applying more environmentally friendly actions (e.g. cold washing, air drying, etc.); and, repair garments if necessary, extending their lifetime.
- After useful lifetime, that is, when the consumer stops using the clothes, if the clothes are already at the end of their life, they must be sent to be recycled, and thus contribute to the circular economy. If the clothes are still in good condition, the consumer can donate, rent or sell them.

The platform encourages the adoption of the good practices mentioned above, through the use of gamification elements.

3.1.1 Scoring

Each action that the user registers on the platform, receives a score. There are three types of scores:

- **Eco-Score** - These points are used to calculate a garment and the user's sustainability index. The user can also increase eco-score points by playing educational games about environmental sustainability, included in the application.
- **Sustainability Points (SP)** - These points can be exchanged for vouchers or other benefits proposed by sponsors.
- **Experience points (XP) (or loyalty points)** - These are points used to encourage the user to use the platform. These points increase whenever the user registers actions on the platform. The quantity of points decrease if the user does not use the application for more than a certain number of days.

All types of points are used to obtain medals. Eco-Score, or eScore, can be defined as an environmental score, or classification, that allows knowing and comparing the environmental impact of the products and of the user's actions.

Table 1 summarizes the set of actions, and the corresponding game points, that can be taken by the consumer and recorded on the proposed platform.

Table 1: Scoring consumer actions.

| Operation/Activity | XP | SP | Eco-Score |
|--------------------|----|----|--|
| Register garment | 1 | 1 | 0 or Garment Eco-Score (from the traceability platform's sustainability index) |
| Wear garment | 5 | 5 | 8 |
| Cold Wash | 2 | 2 | 0 |
| Warm Wash | 1 | 1 | -2 |
| Dry clean | 1 | 0 | -3 |
| Air dry | 2 | 2 | 0 |
| Tumble dry | 1 | 1 | -1 |
| Ironing | 1 | 1 | -1 |
| Repair | 3 | 3 | 2 |
| Swap | 3 | 2 | 2 |
| Sell | 3 | 2 | 2 |
| Donate | 3 | 2 | 2 |
| Send for recycling | 2 | 2 | 1 |
| Send to trash | 1 | -2 | -5 |

3.1.2 The Game Levels

The XP are added to a level bar allowing the user to advance to new game levels. As the gamer moves up the game levels, new educational games are unlocked and the player may be awarded new medals.

3.1.3 The medal system

There is a set of medals that are awarded as the user achieves certain achievements. Some of the proposed achievements and corresponding medals are shown in Table 2.

Table 2: Example of achievements and medals.

| ID | Achievement |
|-----|------------------------------------|
| W1 | Wearing the same garment 50 times |
| W2 | Wearing the same garment 100 times |
| W3 | Wearing the same garment 200 times |
| D1 | First Donation |
| D2 | Donate 10 garments |
| Sh1 | share the first garment |
| Sh2 | share 10 garments |
| S1 | Sold the first garment |
| S2 | Sold 10 garments |
| R2 | Sent 25 items for recycling |
| C1 | Created the first sharing group |

3.2 Platform Requirements and Engineering

The platform's objectives are targeted at encouraging consumers to be more environmentally friendly and engage in CE, while buying, owning and using, and discarding of clothes or other textile items. Thus, the platform's requirements can be grouped into several categories: some are aimed at consuming less; others are oriented towards carrying out more environmentally friendly activities; others to share more clothes; and, others to send clothes for recycling in order to be used for creating raw materials and enter the circular economy.

Figure 1 represents a UML (Unified Modeling Language) use case model, which models the requirements from the point of view of the consumer actor. The consumer is the main participant in the game, who, in addition to performing the tasks identified in the table 1, can create and participate in clothing sharing groups. The consumer can also play educational games.

In addition to the consumer, there are other participants in the game to make it more real and advantageous. So, the platform involve other actors like:

- **Service Provider:** which can be a clothing repair and maintenance company. Service Providers can record maintenance actions for a garment.
- **Brands:** which represents a clothing brand; In addition to being able to register the reception of a piece of clothing to repair, recycle, sell second-hand, Brands can create vouchers and exchange them for points.
- **Recycling companies:** that can register the reception of a piece of clothing for recycling.
- **Sponsors:** Sponsors can be local institutions such as city councils, zoos, etc. who will be able to promote events on the platform and, in return, offer vouchers in exchange for points. For example, a city council could promote an event, such as a half

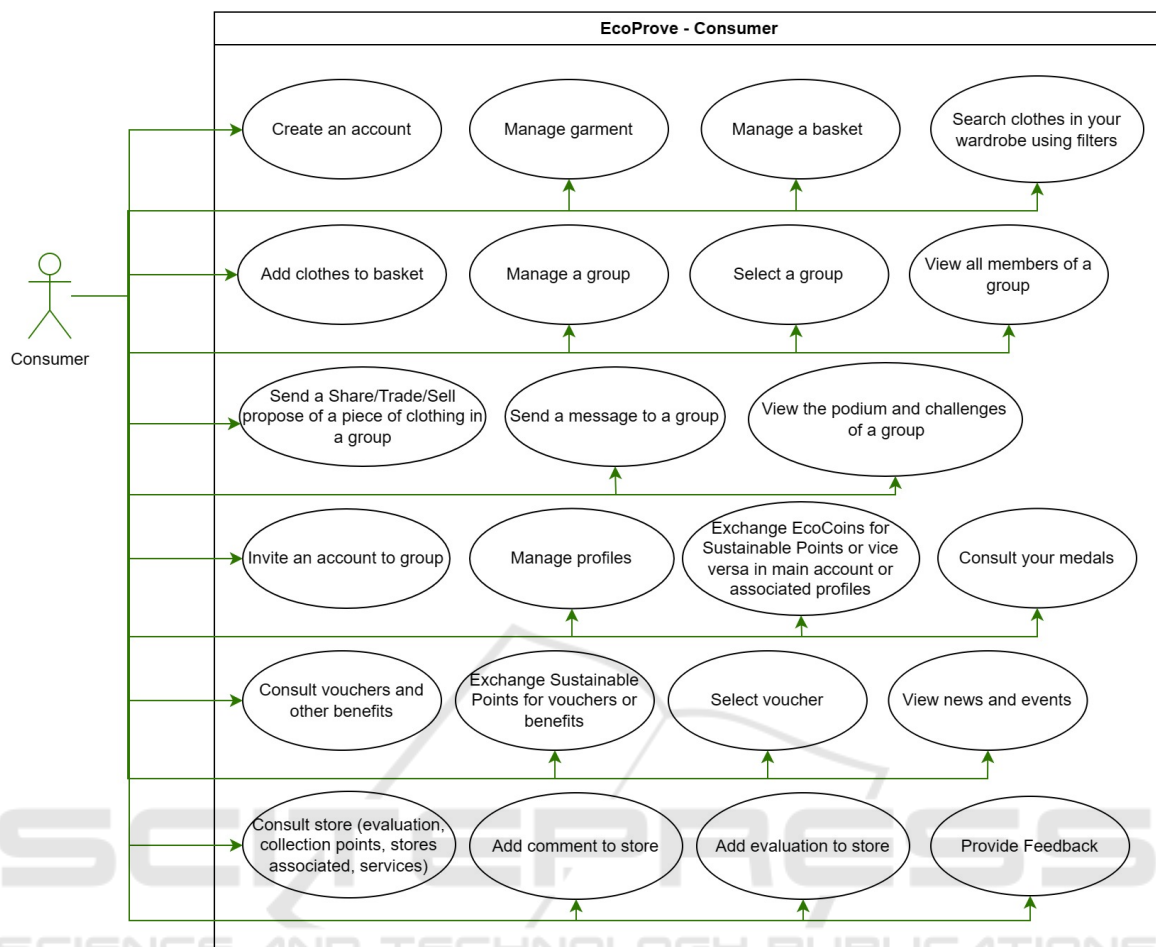


Figure 1: Use case Model for the proposed platform - Consumer.

marathon or nature walk, on the platform and, in return, offer free entry in exchange for points.

All of these actors are able to create and publish vouchers to be exchange for SP and may use the platform to publicize events related to sustainability.

In short, the platform allows consumers to:

- Create and manage their own profile and can create other profiles to manage other clothing closets, e.g. to manage a child’s clothes or to manage the household clothes.
- For a profile, the platform allows to register a garment; record the use of a garment; record the maintenance of a garment (washing; drying; ironing, etc.); record a garment repair or refurb;
- Create an outfit sharing group; Invite friends to the group; Put an outfit in a sharing group; etc.
- View points and medals;
- Exchange points for services;
- Consult statistics such as the most worn garment,

average number of times the garments are used, etc.;

There are two types of groups: private and public. Anyone can belong and participate in public groups, while private groups are only open for participation by users invited by the group creator.

The proposed platform aims to be used by consumers of all ages and genders, so it also includes the possibility of “give a profile independence”, for when a child is old enough and wants to manage their own clothes closet.

In order to improve the usability of the application, the concept of a laundry basket (for washing, ironing, etc.) was created, where the user can add several items and register the maintenance service for all of them at once. The platform allows Service Providers and Brands to register/confirm the repair of a garment; record/confirm the maintenance of a garment; create and promote Services/Events/Vouchers to be exchanged for points; exchange points for services. Some Brands provide containers for collecting

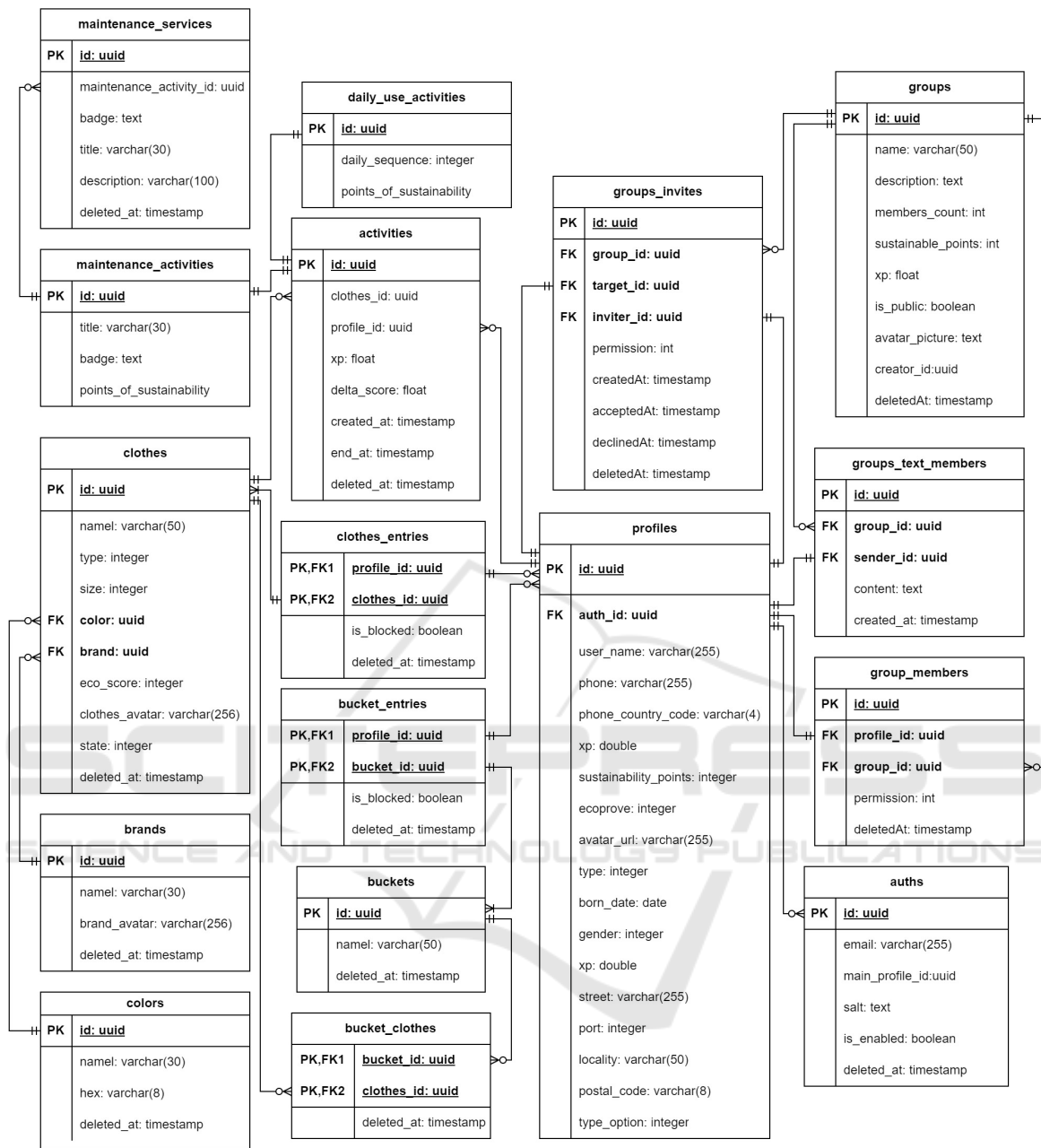


Figure 2: Data Model for the proposed platform, focusing on the end consumer relevant data entities.

items for recycling. Brands and Recycling Companies are able to register the reception of a garment for recycling. Figure 2 represents the data model for the proposed platform. As can be seen in the model, a user *profile* has several *clothes* or clothing items. Each clothe has a *brand* and a main *color*. A user may create a *bucket* for aggregating *clothes* for any purpose, such as for laundry, grouping together for using, or donating. A user *profile* may also create users' groups, and invite other user *profiles* to be a group

member. *Group members* may share text messages (*groups_text_members*) with the group (refer to Figure 2). A user *profile* may register *activities* they make on their the clothes, including the use of clothes in each day (*daily_use_activities*), and maintenance activities (*maintenance_activities*).

3.3 Platform Architecture

Figure 3 depicts the architecture model of the proposed gamification software platform.

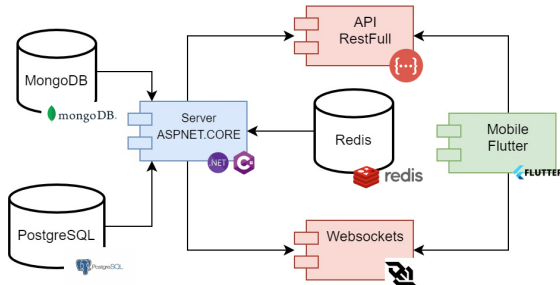


Figure 3: Architecture proposal for the platform.

This architecture comprises two components:

- **Backend:** The backend is responsible for processing requests from the frontend, managing data storage and retrieval, and handling business logic. It consists of two main parts:
 - **API:** The API is a set of rules and protocols that define how the frontend can interact with the backend. In this architecture, the API is built using ASP.NET Core, a cross-platform, open-source framework for building Web applications and services. The API is designed to be RESTful, meaning it adheres to the constraints of the REST architectural style.
 - **Database:** The database is responsible for storing and retrieving data. In this architecture, two types of databases are used: MongoDB, a document-oriented NoSQL database, and PostgreSQL, an open-source relational database management system. PostgreSQL was used as the primary data store, while MongoDB is used for store dynamic data.
- **Frontend:** The frontend is responsible for presenting data to the user and receiving user input. The frontend is a mobile app built using Flutter, an open-source UI software development kit created by Google. Flutter is used for building natively compiled applications for mobile, Web, and desktop from a single codebase. The mobile app communicates with the backend API using HTTP requests and receives data in JSON format.

The architecture also includes caching, session management, and real-time communication technologies:

- **Redis:** A high-performance in-memory data store, was used for store secret information.
- **Websockets:** A protocol for bidirectional, real-time communication between a web browser and

a server. It is used here for implementing real-time features such as chat, live updates, and notifications.

Overall, this architecture provides a scalable, flexible, and efficient solution for building web and mobile applications.

3.4 Mockups

User interface mockups for all use cases of all actors have been developed using Figma². Figure 4 shows four mockup screens. In the first mockup, the user sees the clothes they have in their closet. It should be noted that in the first version the game will be available in Portuguese, as can be seen in the mockups.

The user can select any item for registering an activity on that item. In the second mockup, the user has selected the black pullover. Then, they can mark it as being used (button “*Utilizar*”), or they can select an available activity (refer to the third mockup in Figure 4). If the user selects the option to put the garment into a basket (“*Cesto*”), then, the available baskets are shown for selection (refer to the fourth mockup in Figure 4).

Figure 5 represents a sequence of mockup screens to register a maintenance activity at a service provider. Here, after selecting the black pullover from their closet (see the first two mockups in Figure 5), the user selects the option to send the piece for maintenance (“*Arranjar*”). Then, in the fourth mockup, the system asks the user how the maintenance service will be provided: if it will be carried out by the user (“*Pelo próprio*”), or will be carried out by a service provider registered on the platform as such (“*Serviço*”). If the user selects *Serviço*, then a QR code is shown so that the service provider can read it, telling the system that it has received the clothing item for maintenance (see the last mockup in Figure 5).

4 DISCUSSION AND CONCLUSION

The way a person dresses reflects their personality and influences the opinion that others have about them. Today, people do not just buy clothes because they need to warm up, but often they do it on impulse, because they like to change clothes often. The low quality of clothing, allied to “fast fashion”, leads to increased consumption, making the general population consuming more and more each year. This has led to a huge increase in waste, an unsustainable use of land

²<https://www.figma.com>

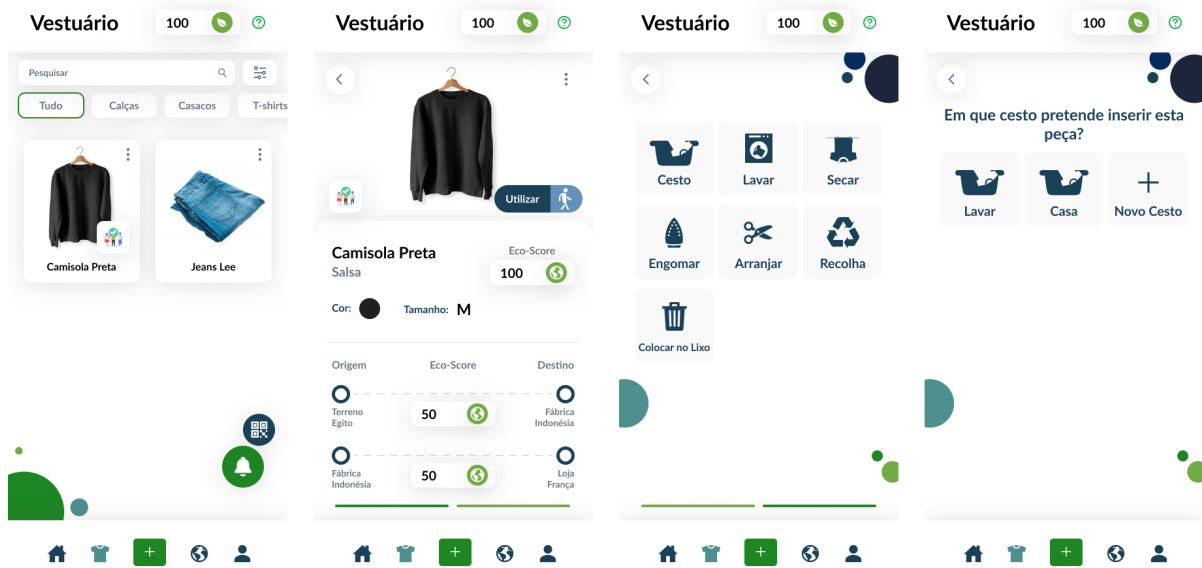


Figure 4: Mockups for registering an activity on a garment/clothing item.



Figure 5: Mockups for stating the use of a garment/clothing item, in a given day.

to produce new raw materials, and a huge increase in water pollution, for the production of clothing, as well as the in air pollution, due to increased products' transportation.

It is necessary to raise awareness among the general population for the need to be more sustainable and contribute to the circular economy. It is necessary to consume less, use the same clothes more often, exchange/donate or sell clothes that are no longer used and, at the end of the clothes' life, the clothes must be sent for recycling.

This article presented a proposal for a platform that, using gaming tactics, looks for involving and "educating" the consumer to be more sustainable and eco-friendly. The platform scores the most environmentally friendly actions for consumers and

awards them with recognition medals. These scoring points can then be exchanged for maintenance services or other vouchers offered by sponsors. The platform involves the entire society: consumers; service providers such as laundries, seamstresses, etc., clothing brands, recycling companies, and local institutions interested in promoting a more sustainable society. The platform also allows the creation of several profiles in order to facilitate the management of the closet, not only the user's own, but also closets from associated user profiles, such as their children's.

As future work, the authors intend to improve the platform so that it can warn about clothes that have not been used for more than a certain period of time, suggesting donating/selling or sending them for recycling. The platform is also intended to provide sug-

gestions on what clothes to wear on the same day or the following day, depending on the weather forecasting, and to provide suggestions on what clothes to pack for a trip. With the information stored, the aim is to understand consumer habits in various aspects such as trends in the use of clothing items, maintenance practices, etc.

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