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Eco-Gamification Platform to Promote Consumers' Engagement in the Textile and Clothing Circular Value Chain

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Abstract: The textile and clothing (T&C) value chain is one of the most polluting in the world and one that produces the most waste. It is, therefore, important to encourage the circular economy (CE) model in this sector to reduce pollution, mitigate the effects of waste production, and, consequently, increase environmental sustainability. Leveraging end-consumer engagement in a CE mindset in the T&C sector is crucial, as they are the last player in a typical linear value chain. Therefore, a platform that supports and promotes sustainable tasks to manage one's fashion products, through the use of gamification techniques, can be of utmost importance. In this article, we identify impactful carbon footprint consumer actions and solutions for the T&C consumer phase. After that, we survey gamification frameworks for analyzing techniques, at the system design level, which enable the engagement of the final consumer in the CE process. Then, we select and use one of such frameworks, Gameful Design Heuristics (GDH), for defining the gamification structure needed to implement on a business-to-consumer-to-consumer (B2C2C) context of a circular economy process, linking it to the aforementioned actions and solutions. As result, we present a B2C2C circular business process model for the T&C value chain and propose the design model of a gamified platform for the final consumers, which allows them to register the consumer-to-business (C2B) and consumer-to-consumer (C2C) activities, from the circular value chain's business process, and benefit from a game-like experience. All the model features have been mapped to the GDH framework heuristics, validating that it is possible to support a set of defined heuristics of applied gamification for promoting CE in the T&C value chain.

Keywords: circular economy; traceability; sustainability; BPMN; eco-gamification; textiles and clothing value chain

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1. Introduction

The textile and clothing (T&C) sector is one of the largest industrial sectors in the world, and one with the greatest impact on the environment [1]. The T&C sector is a great consumer of resources, such as water or fabrics, including synthetic fabrics derived from fossil fuels, and is a great producer of waste and polluting effluents, such as insoluble dyes and heavy metals. In addition, the clothes that are not sold, the so-called "deadstock", end up discarded in a pile of waste or burned [1,2]. The T&C industry sector has a high environmental and social impact. It is one of the most polluting and water-consuming sectors and is often associated with workplace abuses [3].

The T&C value chain is long and complex, spanning several countries throughout the world [4]. This implies great distances in transportation of raw materials and intermediate products and, also, of the final products.

Due to global warming, consumers need to change their attitude and be increasingly vigilant and aware of environmental and social sustainability issues. For this to be achievable, it is imperative to know the environmental impact of a product, and of the ones

that were used in its production, in all stages along its value chain [5,6]. To do that, it is necessary to have traceability platforms that register information regarding sustainability impact in each step along the value chain. One way to mitigate the environmental and social harms of the T&C industry is to engage in circular economy (CE), circularizing the currently linear value chain. CE is an economic system based on a business model that fosters reusing, recycling, and recovering materials in the production/distribution and consumption processes, instead of the currently common "end-of-life" linear concept [7].

Traceability platforms are essential for knowing the environmental impact of every item, which work by tracing and registering data of the environmental impact of each activity in the value chain, including production activities and logistics activities. This allows knowing the environmental impact of any lot of raw materials or of intermediate products, such as yarn or fabric, but also of every lot or item of garments produced for the final consumer.

From the raw material to the creation of the final garment, the T&C value chain involves many different industries, implying several business-to-business (B2B) transactions. When reaching the end consumer, the T&C value chain involves business-to-consumer (B2C) transactions. The inclusion of the consumer-to-consumer (C2C) and consumer-to-business (C2B) activities will allow for closing the loop, circularizing the value chain, as presented in Section 4.1.

In addition to using traceability information for guiding their buying decisions, in a CE process, consumers have an important role in keeping the item in the circular value chain. For this task, consumers need a way to stay motivated and keep doing what is right. What is right, in this case, is to either recover and reuse the product or transfer its ownership, prolonging its lifespan; or deliver it for recycling when reaching its "end-of-life", to be dismantled and used for new raw materials, completing the cycle.

The entire T&C system and its product's lifecycle phases need a holistic circular vision. As depicted in Figure 1, the different stages of the T&C value chain in the core of this multi-layered chart, from upstream to downstream, prioritize reuse, repair, and longer and shared use. Each layer, from inner to outer, represents changes for circular business models, policy options, and education and behavior. These innovations and enablers promote a circular mindset within the T&C sector to mitigate the aforementioned environmental and social impacts that it currently has.

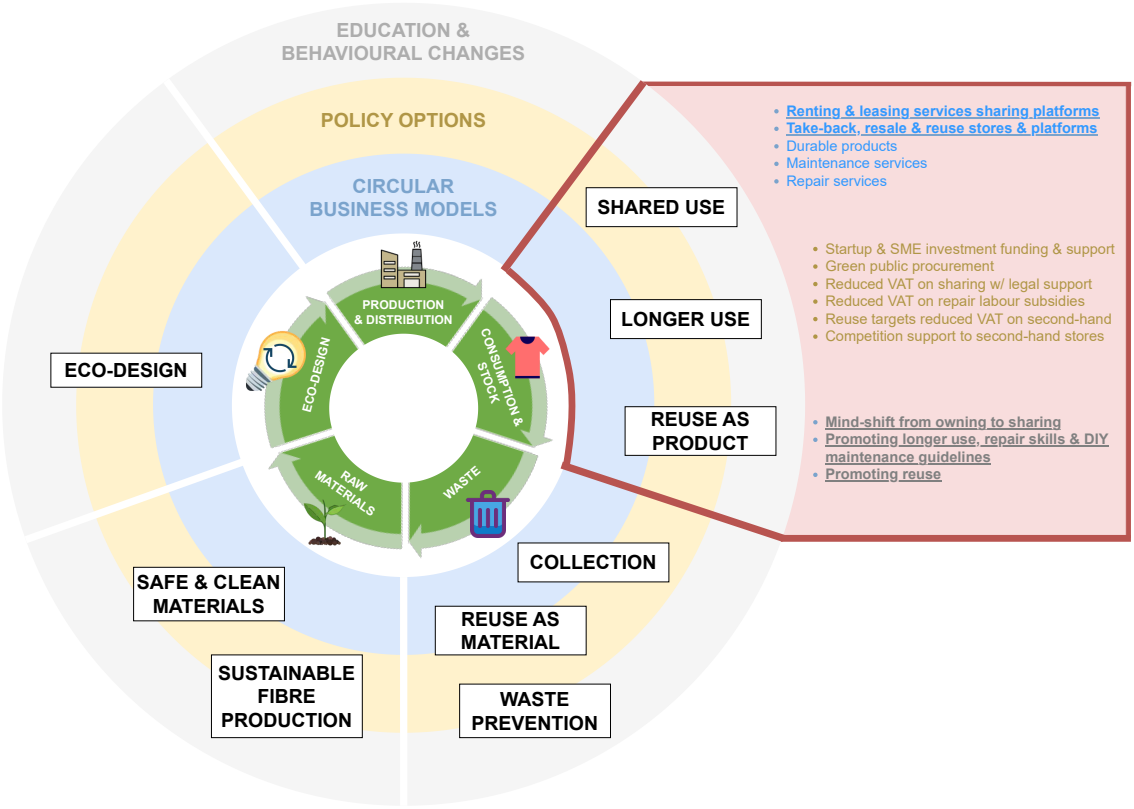

Figure 1. Circular vision for the textiles system (adapted from [8]).

Highlighted in red, and the area of focus of this work, is the consumption/use and stock stage where, for helping consumers to stay focused onto CE, the use of gamification techniques, i.e., using fun and engaging elements typically found in games in a non-game context [9,10], can be of great value when applied to the T&C sector.

In this article, the authors present the evolution of previous work [2,11], i.e., a blockchain-based platform that implements the traceability of the T&C value chain. The proposed platform stores information regarding sustainability indicators for each activity involved in the T&C value chain. This evolution consists of the promotion of the T&C value chain circularization throughout a novel eco-gamification approach to engage consumers into the CE of the T&C value chain and thus contributing with information for the traceability platform.

The article is structured as follows. In the next section, a literature review on gamification techniques is presented, together with an explanation on how these techniques may be used for motivating end consumers to adopt a more sustainable behavior and continue contributing with information to a CE traceability platform. In Section 3, the framework setting of this research and the used methodology is presented. Section 4 presents our proposal for a T&C eco-gamification consumer application (Section 4.2) and conducts a validating mapping of Gameful Design Heuristics to the proposed application model elements (Section 4.2.3). In Section 5, the usability of the proposed prototype is assessed and, in Section 6, a discussion about the theoretical contributions and practical implications of this study is made. Finally, Section 7 draws some conclusions and presents ideas for future work.

2. Literature Review

Digital and non-digital games have been associated with training and leisure, although they can help with performing educational tasks. These games, having educational purposes, use the typical mechanisms of a training game, with the purpose of educating, perceiving, or causing social impact at the cognitive and emotional level. Those dynamics

stimulate the interaction with the game, making the learning process more attractive. The common term used to describe the use of a game with educational purposes, as opposed to the ordinary entertainment purpose, is gamification [12].

2.1. Defining (Eco-)Gamification

First introduced in the early 2000s, but only getting wider adoption in the second half of 2010 [13], the term *gamification*, as described by [9,10], consists of applying certain fun and engaging elements that are usually found in games to a non-game context. Often interpreted as "human-focused design" due to its focus on optimizing human motivation [9], the gamification concept derives from the gaming industry because of its mastery in bringing entertainment and positive experiences to humans. Usually, people play games with the purpose of having fun. If the players are not enjoying it, they leave the game and find other things to do. In this article we will use the term "gamified" to indicate the presence or use of "gamification".

For gamification to effectively work in a specific domain, it should follow a set of motivational perspectives that are not context-dependent. Different motivational outcomes can be triggered by different game design elements [14]. Within the self-determination aspect of motivation, self-determination theory (SDT) seems to be an accepted approach to this field [14]. SDT uses "traditional empirical methods while employing an organismic metatheory that highlights the importance of humans' evolved inner resources for personality development and behavioral self-regulation" [15]. These methods investigate one's tendencies and a total of three needs that make up their own motivation and own personality [15]:

i Relatedness—the universal need to interact and be connected with others;
ii Competence—the universal need to be effective and master a problem in a given environment; and
iii Autonomy—the universal need to control one's own life [13].

These three intrinsic psychological needs are resources that can be shaped with a change in the person's environment, hence the belief that behavior patterns for motivation can be promoted by addressing the human needs for competence, autonomy, and social relatedness [16]. None of these works focus on or even mention the use of gamification techniques.

Regarding the gamification domain, these design techniques for behavior change are applied to several contexts, from self-management to productivity, education, finance, health, news, entertainment, and others [13,17], including sustainability.

"Eco-gamification" or "green gamification" is a concept specifically aimed towards a sustainable environment focused on ecological behaviors. Its foundation is the same as standard gamification, but applying the game elements to sustainability, to make it fun, rewarding, and fulfilling [18]. This results in the so-called "green games", which promote environmentally sustainable behaviors, challenging the player through the proposal of real-life tasks that are aimed to reduce the overall impact on the planet's health. Through the development of these games we can link technological evolution with eco-friendly activities [19].

2.2. Applying Eco-Gamification to a CE Model in the T&C Value Chain

Applying eco-gamification techniques to the CE of the T&C sector is not yet being done. There are eco-gamified systems that promote sustainable goals, as specified in Section 2.3, but regarding the T&C industry, gamification is only being researched for retail and marketing purposes [20]. We have not found any publications on applications for ecological and social sustainability.

With this in mind, Table 1 presents multiple impactful carbon footprint actions and solutions (auditable or not) that consumers can partake in to improve sustainability and contribute to the CE model. There, we can find activities regarding the B2C and C2C area of application, where consumers have multiple choices when considering the acquisition of

a garment (e.g., item circularity, carbon intensity, shopping method, contract), but also the usual garment consumer life-cycle tasks (e.g., laundry and drying amounts and methods, small repairs). Table 1 also displays some solutions that can be audited to track and improve the circularity of products, with the exception of a few that may need to fit General Data Protection Regulation (GDPR) compliance or are simply dependent on the technologies used to identify the product itself. The adoption of eco-gamification methods within a software application that promotes these types of tasks and activities will eventually lead to positive changes in the consumer phase of the garment's lifecycle. When gamification techniques are used by businesses, the goal is, typically, to gain the customers' loyalty by intentionally increasing their engagement [21]. In practical terms, when using gamification in a mobile B2C scenario, companies should focus on improving user interactivity and interpersonal interaction when designing these gamified apps. Jipa et al. in [22] arrive at a similar conclusion, when using a framework based on the technology acceptance model for analyzing and adding gamified characteristics to a value chain's B2C commerce context.

Table 1. Impactful carbon footprint consumer actions and solutions.

Area of Improvement	Action	Solution	Reliable Auditable	References
Item Circularity	Buying NEW items	Buying SECOND-HAND items	✓	[23] [24]
Carbon Intensity	Buying CARBON INTENSIVE items	Buying items with an ECO-FRIENDLY LABEL/GRADE	✓	[23] [25]
Product Longevity	Wearing A FEW times before discard	Wearing MORE times before discard	✗	[26] [27]
Shopping Method	Buying items IN-STORE	Buying items ONLINE	✓	[28,29]
Refunding	REFUNDING to retailer	KEEPING/TRANSFER ownership	✓	[28]
Contract	BUYING items	RENTING items	✓	[27]
Laundry Amount	DOING MANY loads of laundry	DOING FEWER loads of laundry	✗	[30]
Washing Temperature	WARM WASHING items	COLD WASHING items	✗	[30] [31]
Drying Methods	MACHINE DRYING items	AIR DRYING items	✗	[30] [31]
Dry Cleaning Amount	DOING MUCH dry cleaning	DOING LESS dry cleaning	✗	[32] [33]
Refurbishment	NOT REPAIRING items	REPAIRING items	✗	[26]
Disposal	DISCARDING items	TRANSFER item ownership	✓	[24]

2.3. Previous Work on Eco-Gamified Applications

The literature available for gamified sustainability and CE, with the purpose of behavioral change, narrows the domain of sustainability into more precise topics such as sustainable mobility, recycling, or energy consumption. The following research gathers information on gamification techniques for these application topics as well as their results.

In [34], Gustafsson et al. report on the positive outcomes obtained from using the Power Agent game for encouraging teenagers and their families to reduce energy consumption at home. The game elements used in Power Agent provide a storyline, challenge, leveling, feedback, and leaderboards that make the participants highly engaged with the game, consequently resulting in reducing energy consumption.

When it comes to gamification on promoting CE, the Circularity Game [35] explores the combination of these two concepts applied to an existing card deck game for businesses to integrate CE to their models. Using the Octalysis framework [9], the solution's design ranks core drives quantitatively, based on its importance to the final product, while also providing specifically chosen features such as rewards, feedback, customization, and others to hit the targeted core drives.

On the topic of sustainable mobility, the authors in [36] applied several gamification techniques to public transportation of tourists and residents in Madeira, Portugal. With a big pool of gamification methods, the goal was to pick the ones that are best suitable for the creation of engagement for sustainable mobility. They opted by "using awards for the different places that the user visited, progressing on the number of completed adventures and fostering competition for the leaderboard table" as the selected techniques to improve motivation and usage rate.

Within the same realm of sustainable transport, the use of the gamification platform proposed in [37] ends up using several game elements in the public transport application, such as player's state and task progress visualization, quick actions, achievements, challenges, and leaderboards. These game elements are the result of implementing the intrinsic, extrinsic, and context-dependent Gameful Design Heuristics (GDH) framework [38]. The same group of authors also participated in a different study [39], where a similar implementation of this framework resulted in more user engagement with the "Green Game with ViaggiaRovereto" mobile application that it was applied to. Redesigning the platform with motivational characteristics, such as points, badges, achievements, and usage rewards, led to the increase of effectiveness in voluntary travel behavioral change, as well as a gain in incentive to more sustainable transport options.

Previous studies can also be found related to gamification for recycling, such as the work done on the Pantarevir mobile game, presented in [19], which is a good example of how gamification can bring environmental purpose, incentive, and aim (eco-gamification). The authors explore the competitive aspect of a gamified implementation of an eco-friendly activity such as recycling. With the use of a map of layered territories for the users to conquer based on how many cans and bottles they recycle, the end product has succeeded in confirming that it is possible to raise environmental awareness and change recycling habits. That is achieved through the transformation of fun-oriented design of usually tedious habits into something meaningful and entertaining, purposely built in that way. A case study [12] was implemented in the city of Zaragoza, Spain, with the purpose of evaluating an eco-gamified mobile application prototype to encourage waste reduction by increasing recycling rates. The result was an increase in citizens' participation and recycled waste (32.2% and 17.2%, respectively). This was achieved by a reward and achievement system that discounted the rate of waste management services based on how much they had recycled, albeit with a reachable goal set by the city's council.

2.4. Gamification Frameworks

There are several gamification frameworks and methods that evaluate a system's design based on how gamified it is [40]. Some of these, however, can have a set of classifiable dimensions that can be identified and graded, making it possible to have a better perspective on motivational heuristics and metrics for ease of comparison. The authors in [38] analyzed the following measurable frameworks described below.

The developer of the Octalysis framework for gamification design, Yu-Kai Chou, structures the tool in [9] as having eight core drives, which correspond to motivation dimensions that appeal to each person when showing interest in playing a game. These core drives are categorized by feelings (white-hat, black-hat) and by type of motivation/side (extrinsic—left brain, intrinsic—right brain) and are measured and analyzed in a octagonal shape, hence the name Octalysis, outputting a final score regarding the gamification rating.

In the six sided HEXAD model [41], each side is assigned to a user type, which are "personifications of people's intrinsic and extrinsic motivations", supported by SDT that

suggests a binary interpretation to an individual's motivation, with either intrinsic or extrinsic value.

The kaleidoscope of effective gamification (KEG) framework applies a circular layered model, like the layers of an onion, to the motivation dimensions [42]. The layers in the model converge inwards, having an initial outer *Perceived Layer of Fun*, with excitable attributes and elements of surprise for a memorable first impression. As one progresses inward through the model, several other layers appear, such as the Game Design Process Layer, Game Experience Layer, Motivated Behaviour Layer, and, finally, the Effective Gamification Core. This central core of the model sets the nucleus of player experience, which is coherent with all the other layers, representing the main objectives of creating an effective gamification state.

The lens of intrinsic skill atoms (LoISA) framework [17], which the author describes as a way of articulating the main structural components of a gamified system, is a design method based on the concept of lenses and skill atoms. The lenses are a way of interpreting one's design by bundling a principle with a set of questions to take a mental note, to act design-wise, with that principle in mind. The skill atoms are described as a set of skill components associated with the purpose of the previously described lenses.

On the RECIPE for Meaningful Gamification [43], the author explains the given name, through the first letter of its main concepts inspired by Gameful Design: Reflection; Engagement; Choice; Information; Play; Exposition. These elements represent the different metrics that can be applied to gamification for a meaningful (intrinsic) purpose.

Tondello et al. developed Gameful Design Heuristics (GDH), in [38], based on the comparative study between the previous five frameworks, gathering the different measurable motivational dimensions. The resulting heuristics are heavily based on SDT's theory of intrinsic and extrinsic motivation [15,44] and behavioral economics [45] and are classified in a total of 28 heuristics organized within the 12 identified dimensions from the study's analysis. Table 2 (adapted from [38]) summarizes and enables an easy comparison between the six frameworks, with the aim of specifying the set of dimensions of motivational features that those gamification frameworks have.

Table 2. Gamification framework comparison and their dimensions (adapted from [38]).

	Gameful Design Heuristics	Octalysis	HEXAD	KEG	LoISA	RECIPE
Purpose and Meaning	Meaning, Information and Reflection	Epic Meaning and Calling	Philanthropist	N/A	N/A	Information, Reflection
Challenge and Competence	Increasing Challenge, Onboarding, Self-challenge	Development and Accomplishment	Achiever	Motivated Behaviour Layer, Game Experience Layer	Challenge Lenses, Intrinsic Rewards	Engagement
Completeness and Mastery	Progressive Goals, Achievement	Development and Accomplishment	Achiever	Motivated Behaviour Layer, Game Experience Layer	Goal and Action Lenses, Intrinsic Rewards	N/A
Autonomy and Creativity	Choice, Self-expression Freedom	Creativity and Feedback	Free Spirit	Motivated Behaviour Layer	Object Lenses, Intrinsic Rewards	Play, Choice
Relatedness	Social Interaction, Social Cooperation, Social Competition, Fairness	Social Influence and Relatedness	Socialiser	Motivated Behaviour Layer	Intrinsic Rewards	Engagement

Table 2. *Cont.*

	Gameful Design Heuristics	Octalysis	HEXAD	KEG	LoISA	RECIPE
Immersion	Narrative, Perceived Fun	N/A	N/A	Perceived Layer of Fun	N/A	Exposition
Ownership and Rewards	Ownership, Rewards, Virtual Economy	Ownership and Rewards	Player	Motivated Behaviour Layer	Intrinsic Rewards	N/A
Unpredictability	Varied Challenges, Varied Rewards	Unpredictability and Curiosity	Free Spirit	N/A	Varied Challenge, Varied Feedback, Secrets	Play
Scarcity	Scarcity	Scarcity and Impatience	N/A	N/A	N/A	N/A
Loss Avoidance	Loss Avoidance	Loss and Avoidance	N/A	N/A	N/A	N/A
Feedback	Clear and Immediate Feedback, Actionable Feedback, Graspable Progress	Creativity and Feedback	N/A	N/A	Feedback Lenses	N/A
Change and Disruption	Innovation, Disruption Control	N/A	Disruptor	N/A	N/A	N/A
References	[38,41]	[9]	[44] [46] [41]	[42] [44] [47] [48]	[17]	[43] [38]

Based on the aforementioned comparison study, the Gameful Design Heuristics methodology is demonstrated to be a more inclusive tool as a multidimensional approach to evaluate gameful design, and thus it will be used not to evaluate but to define the gamification structure needed to implement it on a business-to-consumer-to-consumer (B2C2C) context of a circular economy, in this case, in the textile and clothing area.

Within the listed set of 12 dimensions, a new set of 28 heuristics has been defined and categorized to hit those dimensions. These heuristics are split into three categories, namely intrinsic motivation, extrinsic motivation, and context-dependent heuristics. In Appendix A, the meaning of each one of these heuristics is disclosed within GDH, and the way that each heuristic may be used to provide gamification resources in a CE context is presented.

3. Materials and Methods

The work described in this article is part of a research project for developing the basis for a circular economy in the T&C value chain. This work is depicted as Phase 3 in Figure 2.

Results from Phases 1 and 2, reported, respectively, in [2] and [11], have provided a traceability platform backend for tracing the environmental and social impact of T&C activities and product lots throughout the business partners in the value chain. This work, Phase 3, aims at studying and selecting gamification techniques for modeling an eco-gamified consumer application.

As noted in the previous section, from the main dimensions of the gamification frameworks reviewed (refer to Table 2), one has concluded that the most suitable gamification framework to implement in a textile CE traceability is GDH [38], due to its high coverage of gamification dimensions, through categorized motivation heuristics. With this in mind, in the next section we will model the proposed T&C eco-gamification consumer application (in Section 4.2) and then validate that the proposed application has elements that are map to the Gameful Design Heuristics (Section 4.2.3).

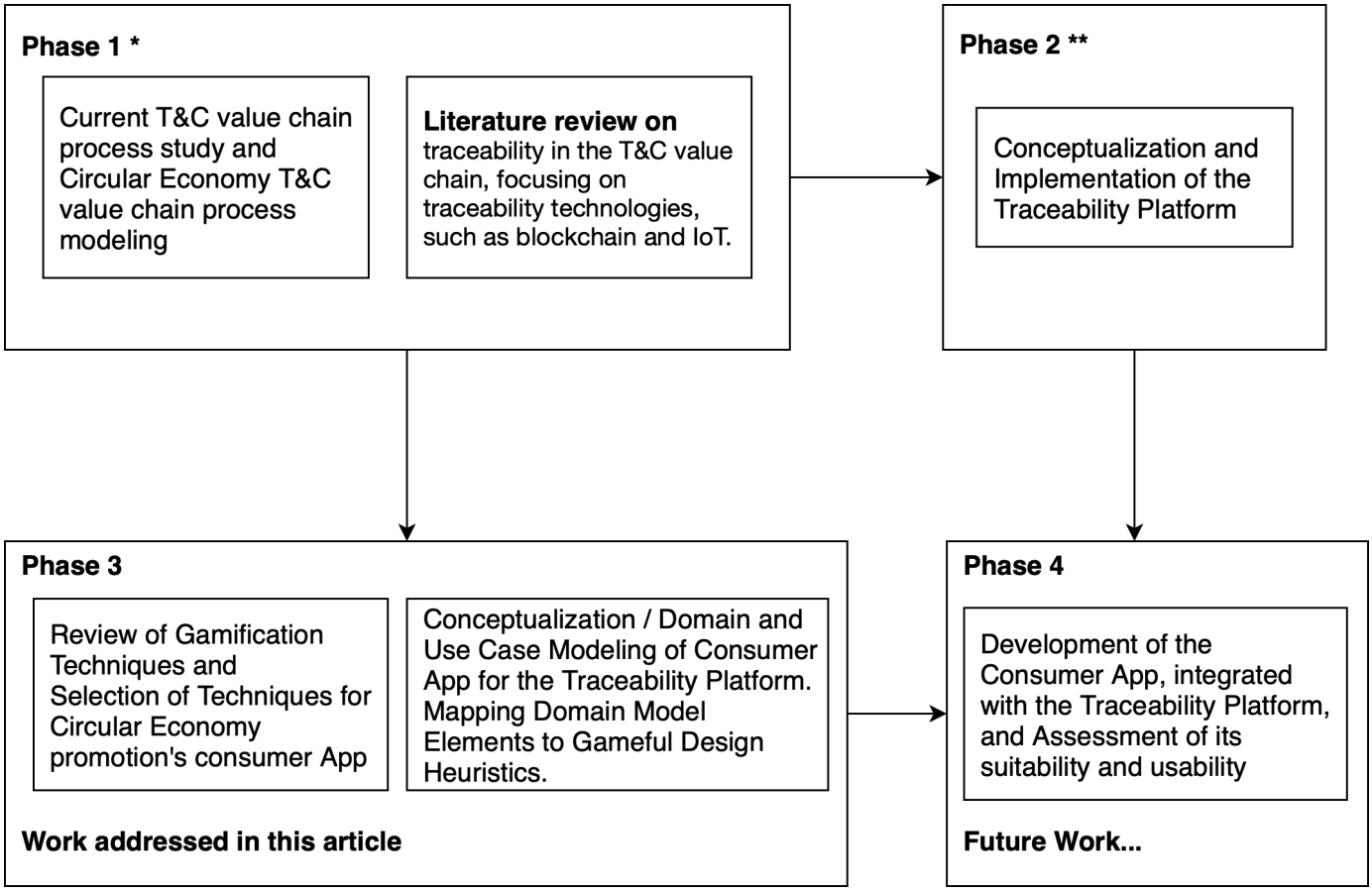

Figure 2. Scheme of research procedure (* published in [2]; ** published in [11]).

4. Results

The T&C industrial sector is undoubtedly fundamental in today's society as well as being a huge sector for economy and employment metrics. However, it is also a current significant contributor to the world's environmental concerns due to its water consumption, pollution by chemical products, CO2 emissions, and huge waste production [1,8].

Through its expansion worldwide, the T&C value chain has turned global, currently involving, from production to consumer, different companies and chain operators located in different countries and continents. This comes alongside the growing need for logistics operations. The manufacturing process handled by the B2B side of the value chain involves activities and operators that deal with the production of T&C and its subcategories (from fiber to garment).

Producing these products consumes great amounts of land, water, energy, chemicals, and fossil fuels. However, the environmental impact of the industry appears throughout the entire life-cycle of a textile product [4], and that includes the consumers that sometimes buy too much and discard it too quickly.

Just on its consumer use phase, in addition to wasting water and energy and using chemicals to maintain its products at consumers' standards, this industry also releases microplastics into the ocean waters. These are fibers released from laundering synthetic textiles. It is estimated that washing these products contributes up to 34.8% to the marine microplastics pollution [49].

It is clear that including the consumer back into the value chain and promoting sustainable tasks with its garments is an aspect that can vastly improve the consumer/use phase of the T&C industry.

4.1. Circularizing the T&C Value Chain

The circular mindset's focus is on decoupling economic growth from resource consumption operating at a micro and macro level. To accomplish this, alternatives to the take–make–dispose model must be found to replace the different aforementioned levels: products, companies, and consumers at a micro level; cities, regions, nations, and beyond at a macro level [50]. The need of a circularity system to stimulate the consumers to rethink the linear take–make–waste model (especially the waste section) and convert it into the CE model, is bigger than ever.

When the T&C CE meets a B2C scenario, the business not only revolves around the interactions between the business operators and the final consumers but also integrates the valuable C2C interactions that can benefit the circularity of the value chain by decreasing disposal. Therefore, we could say that a CE transforms the typical B2C flow into a B2C2C approach.

In Figure 3, a B2C2C circular T&C business process model is proposed using Business Process Model and Notation (BPMN) language. This model extends and complements the model presented in [2], highlighting the activities that can be carried out by consumers to contribute to the CE and emphasizing the well known 3 "R"s (reduce, reuse, recycle) [51]. Among other things, the consumer may reuse items as much as they can before replacing them, and recycle items wherever it is possible, in order to reduce the amount of waste produced.

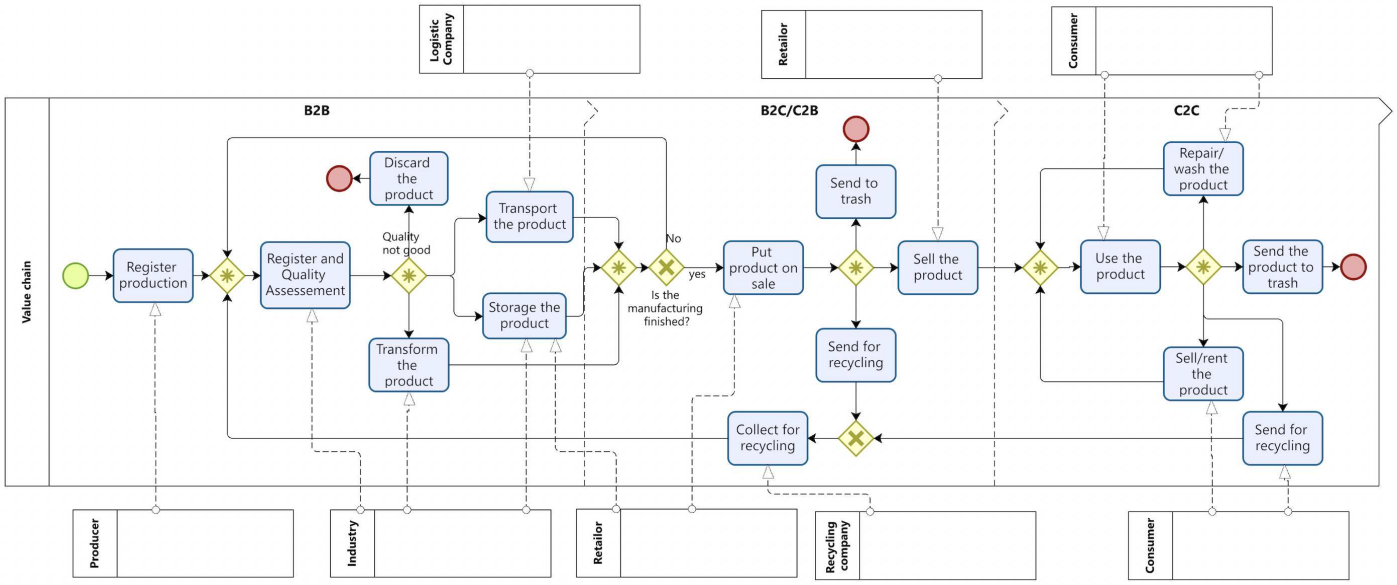

Figure 3. B2C2C circular business model for the T&C value chain.

In Figure 3, the main pool represents the main activities performed in the T&C circular value chain. The operators involved in the B2C2C value chain are represented as external participants. The operator responsible for carrying out an activity is linked to that activity through a sending message (dashed arrow) between the external participant (representing the operator) and the activity. The main operators involved in the T&C circular value chain are:

- *Industry*—representing all types of industry involved in the value chain such as spinning, weaving, sewing, dyeing, and others, including industries that transform recycled items into new raw materials;
- *Retailer*—responsible for selling the products;
- *Logistics company*—responsible for products' transportation;
- *Recycling company*—responsible for collecting textile and clothing items for recycling;

- *Consumer*—a main participant in the chain, who buys products and is able to play an active role in the circularization of the chain;
- *Producers*—despite the circularity of the value chain, the production of new fibers is always necessary. Thus, the participation of *producers*, who produce new fibers, such as cotton or wool, must be maintained, but with less importance.

The main pool is split into three milestones, which represent the main types of businesses involved in a T&C product's life cycle. The process starts with B2B operations (first milestone) for the final product to be manufactured, represented in the BPMN model (Figure 3) by the *Transform the product* activity. These operations are carried out by a set of different industries (e.g., spinning that transforms cotton into yarn, weaving that transforms yarn into fabric, etc.), and between them, there may be transport and/or storage, represented in (Figure 3) by the *Transport the product* and *Store the product* activities. The conceptualization of a blockchain-based platform to support the logging of these B2B activities for a distributed and transparent traceability system was made by the authors in [11]. After those are finished, the final piece will be put to sale by a retailer. The process continues (B2C/C2B milestone) with the sale of the product to the customer, represented in Figure 3 by the *Put product on Sale* activity. At this stage, and according to [1], about 30% of the T&C products are never sold. These products are usually burned, but instead, these T&C products can be recycled, re-entering the cycle and contributing to the circularity of the T&C value chain. The item to be recycled will then be collected and, after a quality assessment, may be selected to be transformed to new raw material for new items of T&C products.

The last milestone (C2C) represents the operations that can be performed by the consumer (or between consumers), and it is the focus of the activities to be logged in the decentralized application (DApp). In order for the T&C value chain to become more environmentally friendly, avoiding waste, etc., the final consumer has a crucial role, by adhering to the CE, helping to close the loop. Thus, the consumer can use the product as many times as possible and for this they may need to wash and/or repair the product several times. When a consumer does not intend, for some reason, to use the product again, they can resell it to another consumer, increasing the lifespan of the product. When the product is at the end of its life, a consumer may send the product for recycling, contributing to the circularity of the T&C value chain.

To close the loop, the recycling company collects the products previously sent for recycling and sends them to an industry operator that, after checking the quality of the products, transforms them into raw material to be used in the creation of new products.

Fibers, especially natural fibers, do not last forever, so it is necessary to check that the materials to be recycled still have sufficient quality to be reused. If this is not the case, the product is discarded, represented in the BPMN model (Figure 3) by the *Discard the product* activity.

The activities represented in the business process model in Figure 3 have a high abstraction level. These activities can be decomposed into processes internal to each of the business operators responsible for the activities and represented in the model by the external participants.

In order to "know the history" of a product and promote the circularity of the T&C value chain, each participant must provide information about their participation in the value chain and must provide all the detailed information of all necessary indicators about the performed activities (production, transformation, transportation, storage, recycling, use, wear, wash, etc.).

For the CE to really be adopted, the participation of the final consumer is essential. To encourage the final consumer to participate in this process, gamification appears to be a good solution. Thus, in the next subsection, the eco-gamified proposed platform is designed, namely the use case models and the domain model are presented.

4.2. Modeling the Proposed Eco-Gamified B2C2C T&C Platform

To support the circular business process model previously presented, this section propose, as a proof-of-concept, an application for the final consumer "to play". The premise of this application consists of the consumers interacting with the system through a mobile application.

As explained in [2], the data collected for each activity of the value chain are stored on the blockchain as a way to guarantee trustless transparency, immutability, and decentralization among the value chain operators. A blockchain wallet system for identification and asset management is proposed for supporting the garment's digital twin transfers between consumers. In this B2C2C scenario, the proposed application will be used in the C2B and C2C activities depicted in the BPMN model in Figure 3.

When doing these activities, consumers need to be registered in the DApp platform, where they can complete challenges, get rewards and achievements, interact with other users, and compete with other users for a sustainable future in the T&C value chain. As an example, let us consider the "Sell/Rent the product" activity from the BPMN process model. When a consumer registers the transfer between users and identifies the new owner, the latter has to confirm the transfer by identifying the garment's tag. When the transaction is confirmed and the transfer is complete, both users will receive rewards, earn badges, complete achievements, and climb the multi-player leaderboards because they took an ecological approach instead of buying and discarding clothes.

By maintaining a digital twin replica of the garments in the DApp and registering their lifecycle activities while in the consumer's use phase, they will be motivated by positively contributing to the T&C value chain by participating in a circular economy model where they get a benefit from it. When the items are sold from consumer to consumer, they are kept in the circular economy and their life is extended instead of being discarded.

The next subsections conceptualize the proposed platform, a Circular B2C2C Eco-Gamified Consumer DApp for the T&C value chain, linking the consumer business model activities in Section 4.1 with the gamified features developed according to the GDH framework. A technological stack is not defined here, with the intent of allowing this architecture to be used within various systems and technologies. Nevertheless, we propose the use of underlying blockchain technology to, independently from any business partner, record and trace B2C2C transactions in the eco-gamified consumer DApp [2,11].

A use case diagram for the proposed platform is presented in Section 4.2.1 to identify the user types and operations on the application. A domain model is also proposed in Section 4.2.2, which defines the entities and their associations that are able to support the user operations depicted in the use case diagram and enable the gamification of most of the consumer activities present in the business process model from Section 4.1. Finally, in Section 4.2.3, we present the justification of the proposed eco-gamified model's structure based on the GDH framework implementation, ensuring that the DApp and its model hit the selected heuristics.

4.2.1. Proposed Platform's Use Case Model

The use case diagram presented in Figure 4 shows what the actors (user profiles), mainly consumers, can do on the application. Reading from top to bottom, the diagram contains use cases related to game data interaction: in the top half are the consumer use cases, and bottom half consists mostly of garments' data and respective transactions.

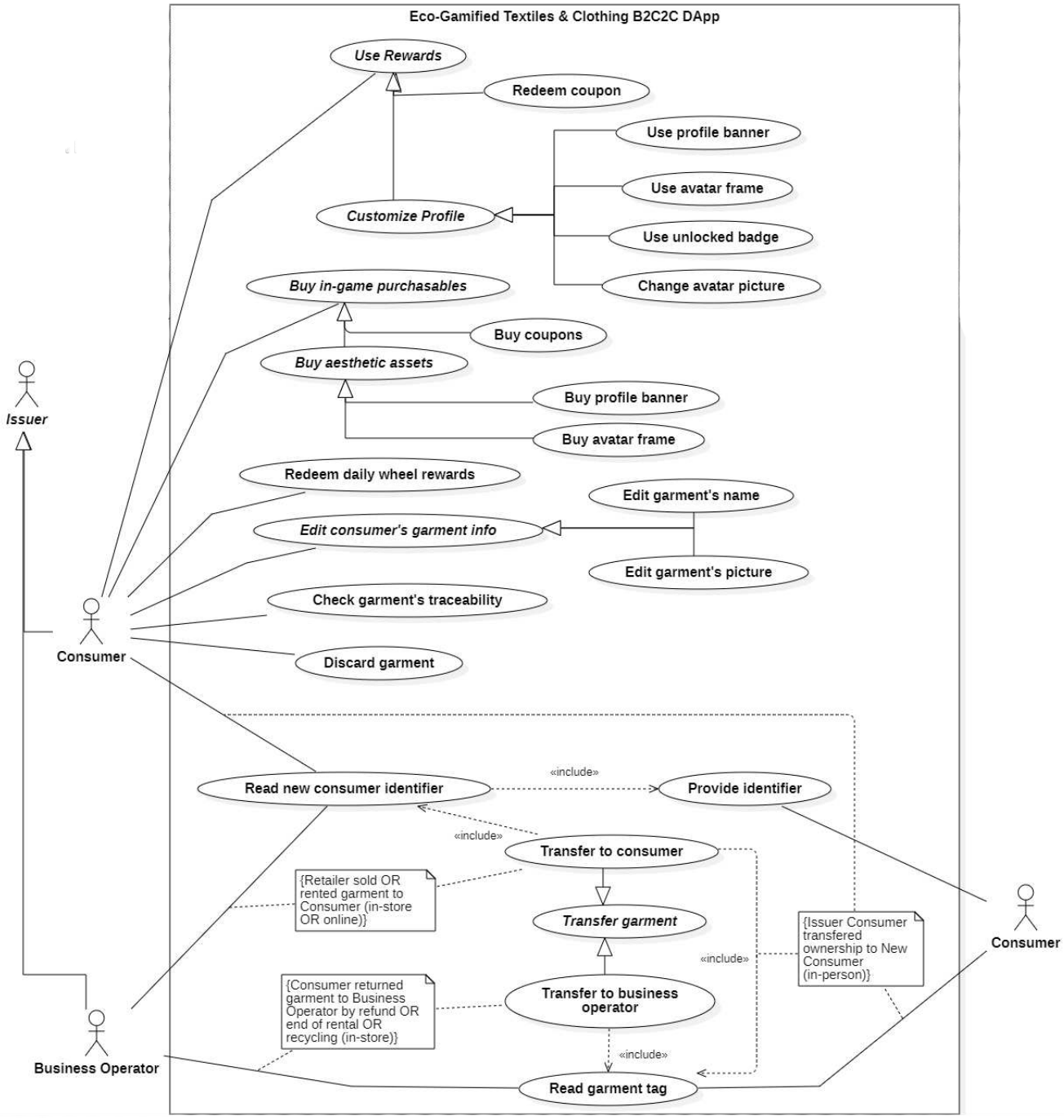

Figure 4. Eco-gamified consumer DApp use case diagram.

A consumer/player can use rewards gained from interacting with the gamified DApp. This includes redeeming coupons from retailers participating in the DApp's economy, ideally to buy garments with high sustainability score or to repair items in need of repair, prolonging their life span, and using those rewards as virtual wearables to customize their in-game user profile. These rewards can be obtained by completing challenges and achievements by interacting with the DApp, by buying them with in-game e-cash, or by redeeming them in a lottery system. Regarding a garment's data, a consumer can edit its information, check its traceability, and discard it, even though this would negatively impact the player in the DApp platform. When transferring the garment between consumers, the new owner can provide its wallet identifier and the previous consumer can read it. When confirming this transfer, the new owner can also read the garment's identifier tag. Another

actor in the system, who can also read the garment's tag, is a business operator, such as a retailer, when a consumer returns a product. It can also read a consumer's identifier to register a transaction when an item is sold or rented.

With this proposed gamification structure, one can now define a model to support these gamified features that reward active participation in the DApp and, consequently, the T&C circular economy.

4.2.2. Proposed Platform's Domain Model

In Figure 5, an eco-gamified UML domain classes model is depicted. The model is divided into three sections, with distinct color-coded areas, which represent three different subjects regarding the proof-of-concept B2C DApp, with which participants (including consumers, retailers, and other operators in addition to the B2B environment) can interact.

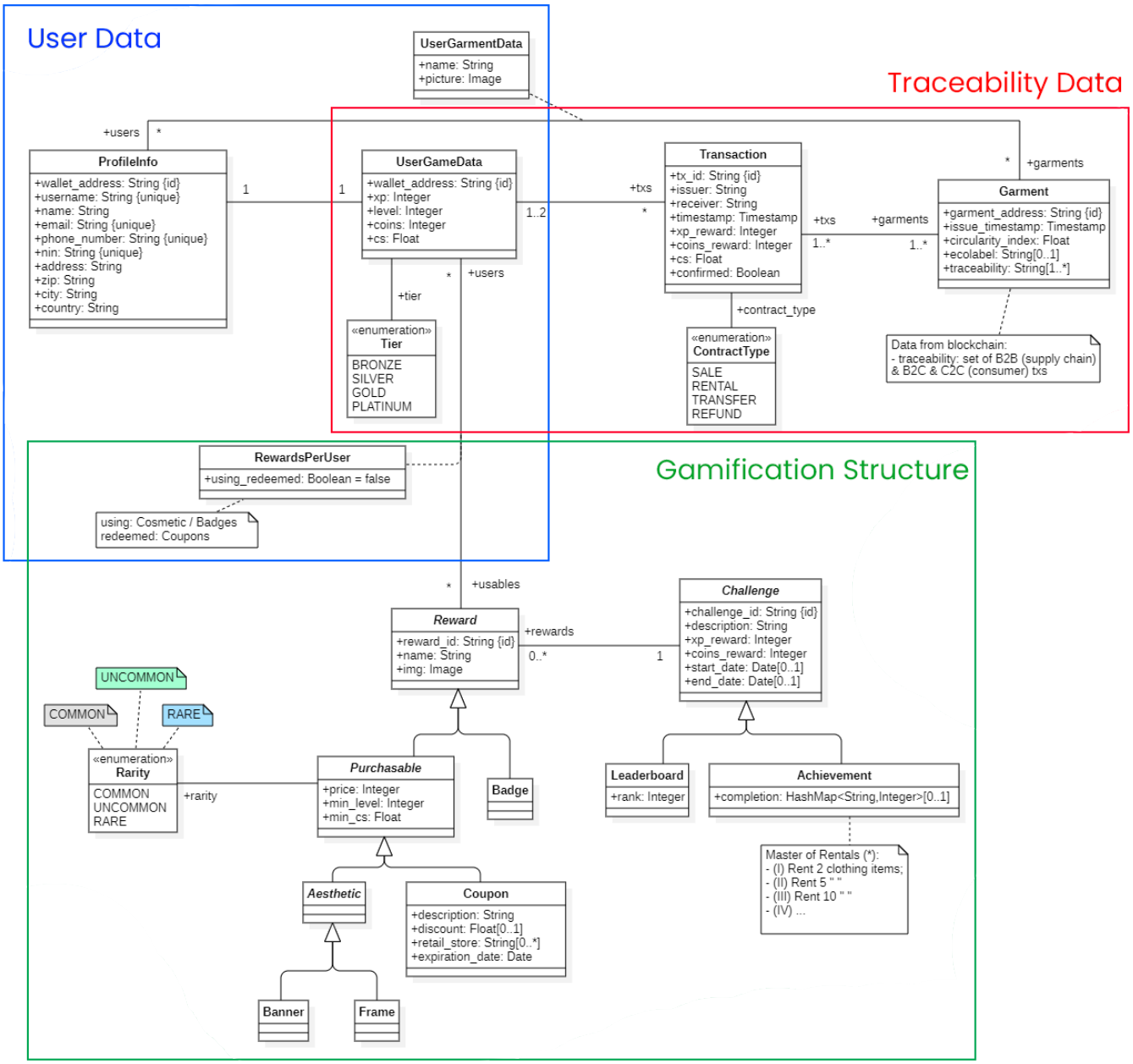

Figure 5. Eco-gamified consumer DApp domain model.

There are also some relevant user game data and metrics defined to create a more game-like experience:

- **Levels and experience points (XP)**—Users can gain XP by completing and/or winning challenges. Users need a minimum XP level to unlock certain rewards (aesthetic and coupons);
- **Coins (in-game e-cash)**—Users are able to purchase rewards (aesthetic and coupons) with in-game coins to customize their profile. Users can get coins by completing and/or winning challenges;
- **Circularity Score (CS)**—The CS is a metric that measures the total sum of CS of each owned clothing item related to its circularity index + CS of eco-friendly auditable actions on these assets.

The three areas specified in the model are Gamification Structure, User Data, and Traceability Data. Some entity classes are related to two of these topics due to some attributes making the connection between different areas of concept. The entity classes are the following:

- **Reward**—A game asset rewarded to the user for completing challenges. Some of these can also be bought in the in-game store with in-game earned coins (purchasable items);
- **Challenge**—An activity in which a user can participate, complete, and get rewarded by completing it successfully (either rewards and/or XP and coins). There are single-player (achievements) and multiplayer (leaderboards) challenges;
- **Rewards Per User**—The active rewards that the user claimed/is using/redeemed. The boolean field *usingOrRedeemed* acts as a validation and verification tool for the badges and aesthetic rewards being used in the user profile as well for indicating which coupons the user has redeemed due to the latter having an expiration date;
- **Profile Info**—Data related to know your customer (KYC) information (username, email, phone number) identified by a wallet address;
- **User Game Data**—Data related to in-game metrics and scores (XP and level, coins, and CS) directly associated to profile info in a one-to-one relationship;
- **User Garment Data**—User custom info related to an owned garment (custom picture and name) identified by the garment and user address;
- **Transaction**—Data related to a garment(s) transaction between two participants on the network, either two consumers or between one consumer and one business operator (hence the 1..2 cardinality on user game data on the one/two-to-many relationship). This cardinality is restricted regarding the transaction's contract type—PURCHASE or REFUND(1), RENTAL or TRANSFER(1..2);
- **Contract Type**—Enumeration type class to define the contractual type of transaction;
- **Garment**—A garment model definition equivalent to the identified digital twin of the piece of clothing in the B2B value chain network. This provides data relative to the garment's circularity index as well as an ecolabel and its traceability transactions (either B2B or B2C). Multiple garments can be added to multiple transactions in the DApp (many-to-many relationship); however, it may be a single transaction per garment process in the backend if we were to use a blockchain-based transaction process.

4.2.3. Mapping Domain Model to Gameful Design Heuristics

To demonstrate which DApp components represent the gamified features implemented in Tables A1–A3, the mapping between the defined heuristics and their implementation in the aforementioned eco-gamified domain model (in Figure 5) and other system components is represented in Table 3.

Table 3. GDH implementation class definition.

Heuristic	Implementation	Supporting Component(s)	Defined Classes and [Attributes]
IMH1	Contributing for a greener and sustainable future	Mobile DApp scope/context	N/A
IMH2	Incentivizing for a textile circular mindset	Mobile DApp scope/context	N/A
IMH3	Difficulty adaptability	Domain Model	UserGameData [XP, Level]
IMH4	Easy challenges for newcomers	Domain Model	UserGameData [XP, Level] Challenge
IMH5	Complete achievements and join multiplayer challenges	Domain Model	Challenge (Leaderboard, Achievement)
IMH6	Leveling system	Domain Model	UserGameData [XP, Level]
IMH7	Challenges progress bar and badges	Domain Model	Achievement [Completion]
IMH8	Different usable rewards	Domain Model	UserGameData [Usables], Reward
IMH9	Customizable personal banner and avatar frame	Domain Model	Aesthetic (Banner, Frame)
IMH10	Experimenting with different clothing and challenges	Domain Model	Reward, Challenge
IMH11	Multiplayer challenges	Domain Model	Challenge
IMH12	N/A	N/A	N/A
IMH13	Competitive challenges and leaderboards	Domain Model	Challenge
IMH14	Partial leaderboards and tier rankings	Domain Model	Challenge
IMH15	N/A	N/A	N/A
IMH16	N/A	N/A	N/A
EMH1	Unlockable usable content	Domain Model	UserGameData [Usables], Reward
EMH2	Badges, coins, XP and other metrics	Domain Model	UserGameData [XP, Level, Coins, CS], Badge
EMH3	Points translate in higher positions in the leaderboard Association to external real-world rewards like coupons	Domain Model	Leaderboard [Rank], Coupon
EMH4	Rarity tiers on rewards	Domain Model	Rarity
EMH5	Timed multiplayer challenges and challenge expiration date	Domain Model	Challenge
CDH1	Push notifications	Architectural Feature	N/A
CDH2	Push notifications	Architectural Feature	N/A
CDH3	Progress bars	Mobile UX/UI	N/A
CDH4	Diverse challenges, both single-player and multiplayer	Domain Model	Challenge
CDH5	Different usables, badges and rewards in the lottery system	Domain Model and Architectural Feature	Reward
CDH6	N/A	N/A	N/A
CDH7	Automatic validation system	Architectural Feature	N/A

As seen in Table 3, several components, such as the Domain Model defined in Section 4.2.2, the DApp's user experience/user interface (UX/UI) scope, and other architectural features, support the conceptual structure of GDH's implementation, previously described in Section 3.

As most of the features are supported by the Domain Model, Table 3 has a column indicating which classes and attributes have been defined to allow the respective heuristic's feature. As an example, we have the intrinsic motivation heuristic **IMH4**, where *Easy challenges for newcomers* would be supported in the Domain Model by defining attributes in an instance of the UserGameData entity, to classify the consumer's ranking by its XP and, therefore, its level. The Challenge entity is also linked to this gamified feature, because users complete challenges that have a defined difficulty based on the consumer's experience with the DApp, making it possible to effortlessly complete a set of challenges in the beginning phases of the DApp's use, increasing difficulty as the consumer progresses through the "game".

4.3. User Interface Prototype

To demonstrate the UX/UI context of an use case in action, Figure 6 shows the in-DApp screen prototypes for two consumers transferring a garment between them. The prototypes in the top row show the previous owner's perspective, whereas the bottom row shows the new owner's screens. The screens' timeline goes from left to right. First, the previous owner selects which garment is intended for transfer, then scans the new owner's identifier (here represented with an QR code). After the new owner's identification, the previous owner will issue the transfer and the new owner needs to confirm it on their side. To confirm it, the new owner can access a menu with pending transfers and select the one they need to confirm. This process relies on a garment confirmation as well, so the new owner needs to scan the garment's identifier tag to confirm that they now own the product. After the confirmation is processed, the new owner receives rewards because an activity that supports the circular economy in the T&C value chain has just been completed. The previous owner will also receive rewards when the garment is identified by the new owner, because his/her participation in this activity was just as important as the participation of the new owner.

The aforementioned use case can cover a lot of the heuristics and means to achieve them, represented in Tables A1–A3, in several realms such as rewards, interaction with other players, competitiveness through challenges, rankings, player progression, and others. This is just one representative use case where we can validate that a set of heuristics is supported by the defined eco-gamified domain model in Figure 5.

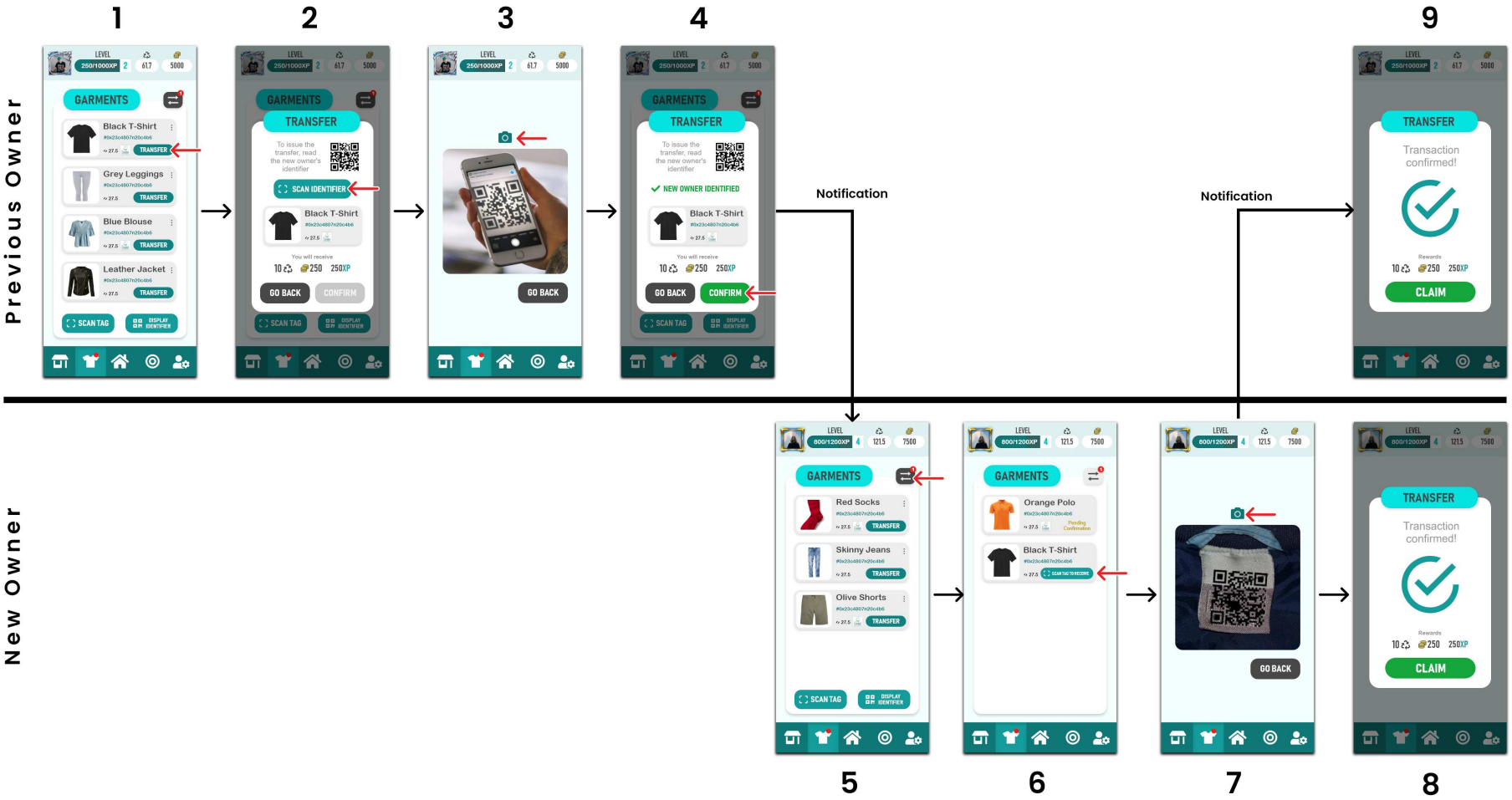

Figure 6. C2C garment transfer use case prototype demonstration.

5. Assessment

To further validate the implementation of the used GDH, usability tests have been applied to the developed DApp prototype. Usability is an important aspect in the evaluation of interactive systems [52].

There are several methods to evaluate usability, including questionnaires that are modeled to focus on different UX/UI dimensions. In [53], the authors compared six different surveys typically used in usability evaluations and assessed the dimensions of focus of the questionnaires. The results had the following set of defined dimensions:

- Generic UX;
- Affect/Emotion;
- Enjoyment/Fun;
- Aesthetics/Appeal;
- Hedonic Quality;
- Engagement/Flow;
- Motivation;
- Enchantment;
- Frustration;
- Pragmatic Quality.

Considering the main objective of the defined DApp (Section 4.2), which is to motivate and promote consumer participation in circular economy through the implementation of the GDH framework, the chosen questionnaire to be used in these usability tests has been AttrakDiff because it has the most impact in the **Engagement/Flow** and **Motivation** dimensions according to [53].

5.1. AttrakDiff

AttrakDiff (www.attrakdiff.de, accessed on 21 November 2022) is one of the most frequently used standardized questionnaires in the human–computer interaction (HCI) field to evaluate the usability of an interactive product. The theoretical principle on which AttrakDiff is based is that a product can have two main qualities: pragmatic and hedonic. Pragmatic qualities (PQ) are more objective and support instrumental and task-related features of a product, ensuring effective and efficient means to perform a task. On the other hand, hedonic qualities (HQ) are more subjective and support stimulation (HQ-S), communicate identity (HQ-I), and provoke memory [54]. The separation of the stimulation and identification sub-qualities became preferable upon the development of the AttrakDiff survey, as it provides more result optimization. Hedonic and pragmatic qualities are perceived consistently and independent of one another. Both contribute equally to the rating of attractiveness (ATT).

5.2. Assessment Data

AttrakDiff assesses the user's feelings about the system in a questionnaire with 28 seven-step items whose poles are opposite adjectives (e.g., "confusing–clear", "unusual–ordinary", "good–bad"). Each set of adjective items is ordered into a scale of intensity. It produces quantitative comparative data that are optimal for analysis purposes.

We asked a group of 20 people with different backgrounds, ages, and gender to test our DApp's usability through the AttrakDiff survey available in www.attrakdiff.de (accessed on 21 November 2022). For participant recruitment, an invitation was sent to the authors' academic mailing lists (for students, teachers, and non-teaching staff). They were invited to forward the request to family members.

The sum of all answered questions can be found in Appendix B.

5.3. Analysis

AttrakDiff's official platform (www.attrakdiff.de, accessed on 21 November 2022) also provided us with some analytics and diagrams that helped us notice key information about the usability of the developed DApp that we have named "Green Closet" as an example.

In Figure 7, we can see the different adjective pairs that are used to describe the system in the questionnaire, going from left-to-right in order of overall preference. The pairs are grouped by their respective association with the aforementioned pragmatic qualities, hedonic-identification qualities, hedonic-stimulation qualities, and attractiveness. The mean values of the word pairs are presented on the blue line. Of particular interest are the extreme values because these show which characteristics are particularly critical or particularly well-resolved. It is also intended that the values should be positive as a confirmation of well implemented design for the overall appeal of the DApp. Based on these results, we can see that the "technical–human" and "cheap–premium" pair values stand out negatively, as it is probable that this is an area of improvement.

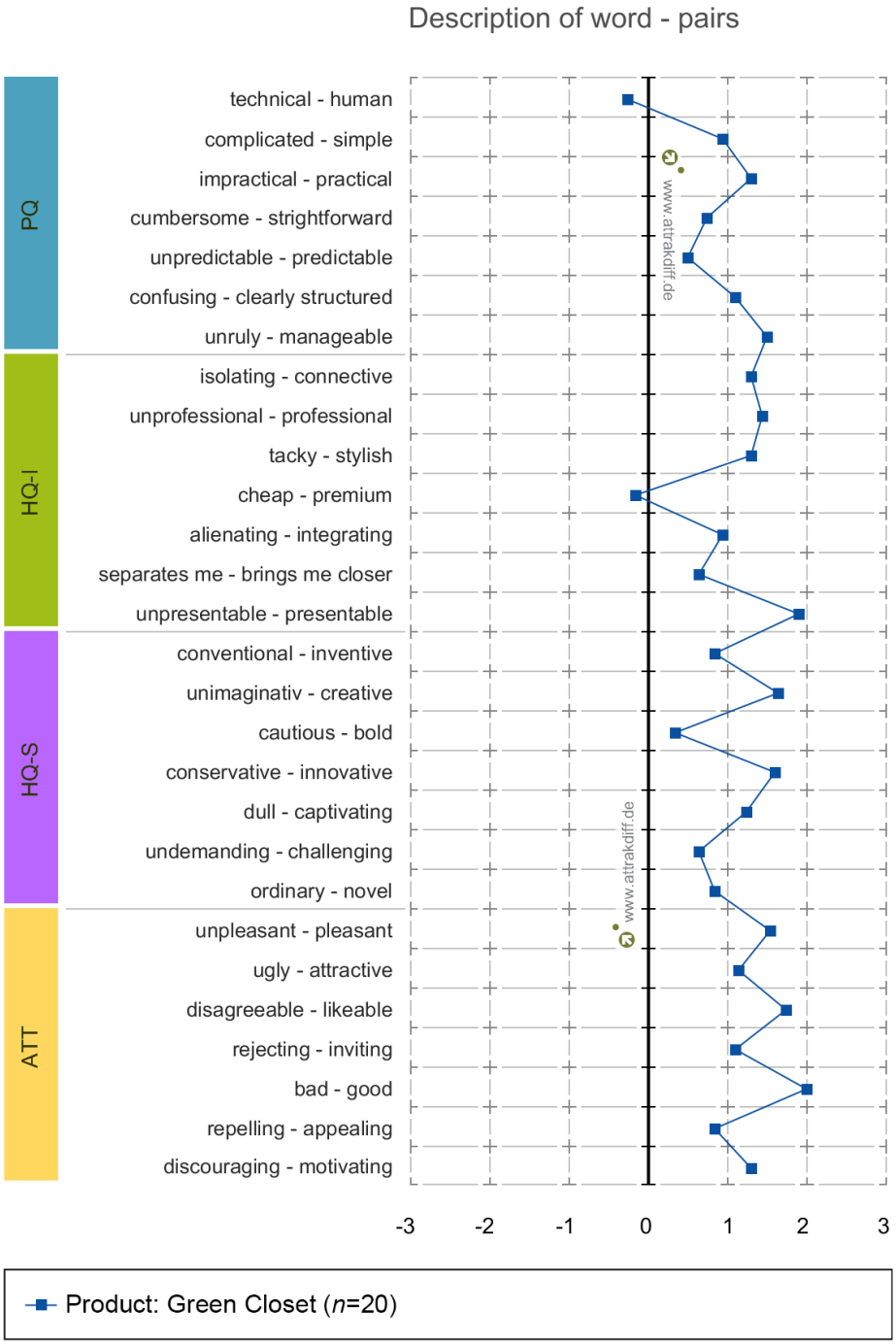

Figure 7. AttrakDiff's results—word pairs' average values.

In Figure 8, we can see a more abstract interpretation of the results previously detailed. Every quality category is close to a positive score of 1. Pragmatic qualities have the lowest score, with 0.84, and overall attractiveness has the highest score, with 1.39. It is worth noting that both identification HQs and stimulation HQs had similar averages, with 1.06 and 1.03, respectively.

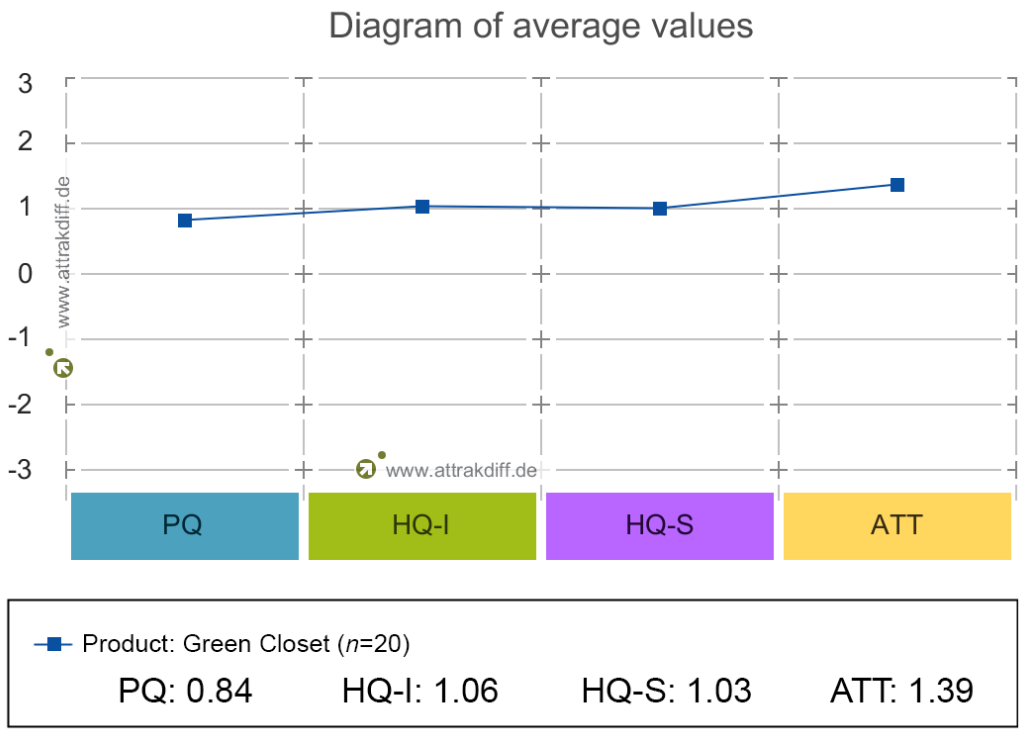

Figure 8. AttrakDiff's results—average value per quality category.

Finally, in Figure 9, an XY diagram (called a portfolio) is presented. The horizontal axis (X) shows the pragmatic quality, and the vertical axis (Y) of the portfolio view displays the hedonic quality. Depending on the dimensions' values, the inner blue square, representing the product, will lie in or near one of the defined nine "character-regions". Around the square's placement there is a lighter blue rectangle that represents the result confidence. The bigger the confidence rectangle, the less sure one can be as to which region it belongs. A small confidence rectangle is an advantage because it means that the investigation results are more reliable and less coincidental. The confidence rectangle shows whether the users are somewhat agreeing in their evaluation of the product. The prototyped "Green Closet" DApp rates between **self-oriented** and **neutral**, but the uncertainty of the assessment results can bring the system to **task-oriented** or even **desired**. In the next section, a brief discussion is developed.

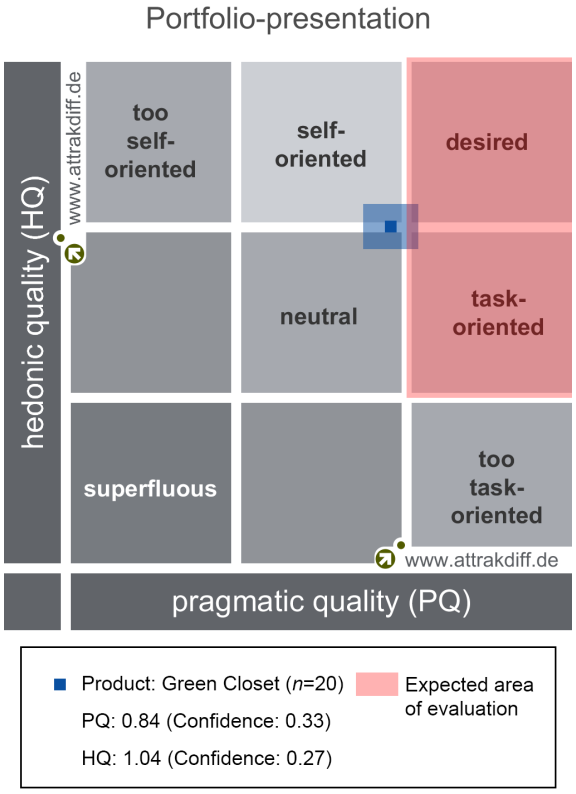

Figure 9. AttrakDiff's results—portfolio.

6. Discussion

The CE is an environmentally sustainable economic model, especially when compared to the today's most common "end-of-life" linear business model. As noted earlier, the circularity of a circular economic model is only possible with the participation of the final consumer. He/she is the one who acquires the product at the end of the production/distribution chain, and delivers it, or not, for recycling at the end of what he/she considers to be the product's useful life time. Additionally, consumers, during the period of time they own and use the product, can make decisions with greater or lesser environmental impact. This is the time period when a consumer-targeted mobile application can promote their engagement in making decisions that have less impact on the environment. This end-consumer-targeted application may be more or less capable of involving the consumer in the circular economy. The use of gamification techniques contributes to improving this capacity.

We have surveyed a set of gamification frameworks and compared their main motivational features, or dimensions that their heuristics target, which allow for evaluating the functional and UI/XP characteristics of a software application towards each dimension objective. From this survey, GDH has been selected to guide the development of a consumer-targeted mobile app, both to identify the functional features and supporting data structures (refer to Section 4.2) and to design its user interface (Section 4.3).

The UI/XP evaluation made to the developed application prototype is promising. The assessment results described in the previous section, although not the best possible, allow us to perceive that the proposed application is marginally considered as "self-oriented", "task-oriented", and "desired" (see Figure 9). There is a lack of pragmatic qualities in the DApp, as the score from pragmatic qualities (PQ) deviates from the average score of HQ (0.84 to 1.045, respectively). This leads to a greater area coverage of the product's usability within the **self-oriented** and **neutral** sections. These results are not fully what was expected, because the intended evaluation of the DApp's usability should be closer to a **task-oriented** product.

Unlike a self-oriented product, a task-oriented product is what will lead to users contributing with more sustainable actions by performing the tasks on the DApp. This positively contributes to the sustainability of the T&C value chain by promoting the circular economy model between consumers/DApp users and business operators, as depicted in Figure 10.

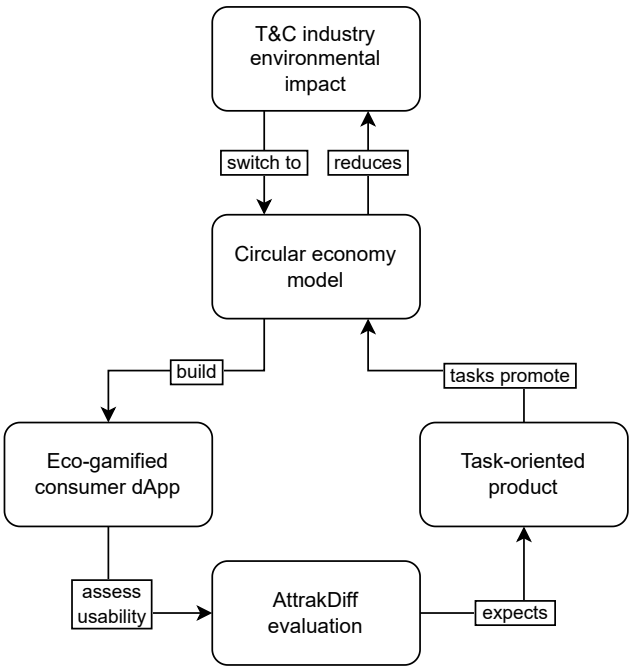

Figure 10. Task-oriented product expectation flowchart.

Thus, an improvement of the application's hedonic qualities and of its pragmatic qualities would allow pushing this classification towards the "desired" section of the assessment results portfolio.

This type of consumer-targeted applications is promissing in involving consumers towards circular economy in the T&C value chain. Consumers game is played in real life, by taking environmentally friendly decisions, but this application allows them to be rewarded while playing the real-life game, promoting the continuous reuse of materials and resources, allowing the reduction of waste and the preservation of natural resources.

7. Conclusions

There is an undeniable and urgent need to circularize the value chain process of the textiles and clothing economic sector. To achieve this circular economy end goal, the final consumer's participation is imperative to fully circularize the value chain. As a means to promote the consumer's engagement and his/her willingness to be part of the T&C circular model, a B2C2C DApp has been conceptualized with gamification features. This way, the consumer can be intrinsically and extrinsically motivated to positively contribute to the value chain through rewards and other in-game bonuses.

By registering lifecycle activities of a garment inside the DApp, the consumers (players) are rewarded within the game's environment, which can lead to real-life tangible benefits. As the prototyped DApp is meant to be a digital representation of the T&C on a B2C2C context, rewarding the consumer through circular adoption and game-like features is a way of motivating users to actively and positively contribute to a greener supply chain. In this context, we verify today's relevance to consider the use of gamification on a system for increasing consumer participation in a CE value chain due to the consumer's importance in helping to contribute to a more sustainable society.

The modeling of an eco-gamified DApp has been developed, and its model features have been mapped to GDH framework heuristics, validating that it is possible to support a set of defined heuristics of applied gamification for promoting CE in the T&C value chain. Based on the DApp modeling, in Section 4.2, it is possible to create, as future work, an eco-gamified consumer DApp to support the premise of this work—promote consumer's engagement in the circular T&C value chain. This engagement is measurable by analyzing our DApp design through usability testing such as AttrakDiff surveys, as noted in Section 5.3. According to the results obtained, people who tried the prototype and responded to the AttrakDiff survey had an overall positive experience with the prototype, leading us to conclude that motivation and engagement to use DApp are taken into account by design, sometimes without even considering its gamification aspect.

Regarding future improvements of this work, there is the possibility to improve the GDH's implementation in Tables A1–A3 by creating more game data assets that strengthen the motivation towards the DApp's objective. Some of these may include:

- **In IMH2.** Cooperative challenges—Cooperative challenges can bring users together for increased group motivation;
- **In IMH15.** Meaningful sustainable awareness narrative supported by the game—By constantly reminding the user of the inherent narrative motive behind the application, users can be immersed into a new reality within the game space;
- **In IMH16.** System feedback on sustainable contribution (percentages, etc.)—The system should be able to provide feedback on how much they contributed to the CE within their supply chains;
- **In CDH6.** In-game surveys—With the use of in-game surveys and game feedback forms, the players have an opportunity to give new ideas.

As a way to comply with certain T&C value chain workflow requirements, a garment's identification could be swapped from a single unit ID tag to the garment's batch ID tag. That would imply some changes in the DApp's domain model.

To inter-operate between the B2B and C2C domains, a reformulation of access to the B2B data with integration of the developed DApp can be a way to easily stream trustworthy information between business operators and consumers, leading to an increase of transparency.

Finally, based on the results we had on the usability test (Section 5.3), the design of the DApp can be improved so that the under-performing aspects (especially pragmatic qualities) that came to light in the AttrakDiff survey would have better usability results.

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Conflicts of Interest: The authors declare no conflict of interest.

Abbreviations

The following abbreviations are used in this manuscript:

BPMN	Business Process Model and Notation
B2C2C	Business-to-Consumer-to-Consumer
B2C	Business-to-Consumer
B2B2C	Business-to-Business-to-Consumer
B2B2C2C	Business-to-Business-to-Consumer-to-Consumer
B2B	Business-to-Business
CDH	Context-Dependent Heuristic
C2C	Consumer-to-Consumer
C2B	Consumer-to-Business
CE	Circular Economy
CS	Circularity Score
DApp	Decentralized Application
EMH	Extrinsic Motivation Heuristic
GDH	Gameful Design Heuristics
GDPR	General Data Protection Regulation
HCI	Human–Computer Interaction
HQ	Hedonic Qualities
IMH	Intrinsic Motivation Heuristic
KEG	Kaleidoscope of Effective Gamification
KYC	Know Your Customer
LoISA	Lens of Intrinsic Skill Atoms
PQ	Pragmatic Qualities
SDT	Self-Determination Theory
T&C	Textile and Clothing
UNECE	United Nations Economic Commission for Europe
UX/UI	User Experience/User Interface
XP	eXperience Points

Appendix A

Tables A1–A3 show how the framework GDH may be used in providing multiple gamification resources that focus on different motivation heuristics.

Table A1. GDH implementation on textile CE B2C applications—Part I.

Intrinsic Motivation Heuristics		Framework Implementation
Purpose and Meaning		
IMH1. Meaning	- Identification of meaningful contribution	- Contributing for a greener and sustainable future
IMH2. Information and Reflection	- Information and reflection towards self-improvement	- Incentivizing for a textile circular mindset
Challenge and Competence		
IMH3. Increased Challenge	- Challenges that grow with users' skills	- Difficulty adaptability
IMH4. Onboarding	- Challenges for newcomers	- Easy challenges for newcomers
IMH5. Self-challenge	- Discover or create new challenges	- Complete achievements and join multiplayer challenges
Completeness and Mastery		
IMH6. Progressive Goals	- Next goal achievable is presented	- Leveling system
IMH7. Achievement	- Monitoring of achievements or advancements	- Challenges progress bar and badges

Table A1. *Cont.*

Intrinsic Motivation Heuristics		Framework Implementation
Autonomy and Creativity		
IMH8. Choice	- Possibility to make choices, limited by users' abilities	- Different usable rewards
IMH9. Self-expression	- Create new content	- Customizable personal banner and avatar frame
IMH10. Freedom	- Possibility of experimenting without serious consequences	- Experimenting with different clothing and challenges
Relatedness		
IMH11. Social Interaction	- Possibility to connect with others	- Multiplayer challenges
IMH12. Social Cooperation	- Possibility to work with others to achieve a common goal	-
IMH13. Social Competition	- Possibility to challenge or compare with others	- Competitive challenges and leaderboards
IMH14. Fairness	- Opportunities to success and progression also for newcomers	- Partial leaderboards and tier rankings
Immersion		
IMH15. Narrative	- Meaningful story	-
IMH16. Perceived Fun	- Possibility to interact and be part of the story	-

Table A2. GDH implementation on textile CE B2C applications—Part II.

Extrinsic Motivation Heuristics		Framework Implementation
Ownership and Rewards		
EMH1. Ownership	- Possibility to possess virtual goods or build a profile over time	- Unlockable usable content
EMH2. Rewards	- Reward system to incentive interactions and continued use	- Badges, coins, XP, and other metrics
EMH3. Virtual Economy	- Results can be exchanged for in-system and outside rewards	- Points translate in higher positions in the leaderboard - Association to external real-world rewards like coupons
Scarcity		
EMH4. Scarcity	- Presence of rare rewards or items	- Rarity tiers on rewards
Loss Avoidance		
EMH5. Loss Avoidance	- Urgency to act immediately to avoid possible losses	- Timed multiplayer challenges and challenge expiration date

Table A3. GDH implementation on textile CE B2C applications—Part III.

Context-Dependent Heuristics		Framework Implementation
Feedback		
CDH1. Clean and Immediate Feedback	- Immediate feedback of changes or accomplishments	- Push notifications
CDH2. Actionable Feedback	- Information on the next available action	- Push notifications
CDH3. Graspable Progress	- Information on the users' path ahead for progression	- Progress bars
Unpredictability		
CDH4. Varied Challenges	- Heterogeneity of the task presented	- Diverse challenges, both single-player and multiplayer
CDH5. Varied Rewards	- Heterogeneity of the rewards offered	- Different usables, badges and rewards in the lottery system
Challenge and Disruption		
CDH6. Innovation	- Possibility to contribute with ideas and content for the users	-
CDH7. Disruption Control	- Cheating control	- Automatic validation system

Part of the solutions provided are suggested in [37], where the same framework, although with fewer heuristics, was implemented on an eco-gamified context. Here, we added another set of solutions to complete the missing ones in the entire list of heuristics. Going through the table with the GDH implementation on B2C applications for textile CE, we have:

Intrinsic motivation relates to the internal needs defined in SDT as well as other factors present in SDT's literature [15,44,46]. This category includes the following dimensions: *Purpose and Meaning, Challenge and Competence, Completeness and Mastery, Autonomy and Creativity, Relatedness, and Immersion*. The items in the list below represent each IMH (refer to the first part of Table A1):

- **IMH1.** No resources needed because the gamified context is built to a purposeful sustainable textile future;
- **IMH2.** Like IMH1, the app's domain revolves around a textile circular mindset and provides information for the users to make a self-made decision to contribute;
- **IMH3.** With a difficulty adjustable challenge mechanism based on how experienced the user is, it is possible to provide new engaging missions/quests;
- **IMH4.** The first steps in the app should be easy for the newcomers so that they do not get "lost" and overwhelmed when first experiencing the system;
- **IMH5.** Creation of harder challenges for self-improvement;
- **IMH6.** A simple leveling system for comparison with other users and motivation;
- **IMH7.** Progress bars and achievement badges are used for completeness purposes;
- **IMH8.** Users are able to choose which unlockables they want to use;
- **IMH9.** With the ability to customize their personable banner and avatar, the users can create new content;
- **IMH10.** Different garments can be recycled and re-used in the system so users can experiment the circular mindset on various textile products;
- **IMH11.** Multiplayer challenges (cooperative or competitive) provide the needed interaction for relatedness;
- **IMH13.** Competitive challenges bring the more intense competition and extra motivation to achieve circularity;
- **IMH14.** By having different tier rankings, new users can experience winning and thus have an opportunity of succeeding in the system.

Extrinsic motivation is for heuristics that produce a certain outcome decoupled from what the player is doing [9,44]. This category includes the following dimensions: *Ownership and Rewards, Scarcity, and Loss Avoidance*. The items in the list below represent each EMH (refer to the scond part of Table A2):

- **EMH1.** Ownable content (custom banners/avatars/badges) brings the ability to possess virtual items;
- **EMH2.** By having points related to user experience and a leveling system and e-cash, the gamified app rewards user actions;
- **EMH3.** The aforementioned e-cash should be used to get other in-game goods;
- **EMH4.** With the use of a kind of in-game lottery system or "wheel of fortune", which rewards users with items of different rarities, the app can bring the feel of scarcity to motivate the players;
- **EMH5.** Setting an expiration date on a challenge creates the FOMO effect (fear of missing out).

Context-dependent heuristics can be either intrinsic or extrinsic depending on the context—*Feedback*, for example. This category includes the following dimensions: *Feedback, Unpredictability, and Change and Disruption*. The items in the list below represent each CDH (refer to the third and last part of Table A3):

- **CDH1.** A way to keep users engaged is to provide feedback with push notifications, so that they immediately know information about their current activities;

- **CDH2.** The way CDH1 provides feedback for users current activities, the same should be done for their next and future activities;
- **CDH3.** A progress indicator such as a bar is a way of visualizing how much is needed to get to the next step;
- **CDH4.** The application should provide different challenges on various cyclical and random patterns to avoid monotony;
- **CDH5.** The same concept of heterogeneity present in CDH4 should be applied to the reward and lottery system;
- **CDH7.** Automatic validation systems and anti-cheating features can bring integrity to the data and, consequently, to the application.

Appendix B

Table A4. AttrakDiff's results—questionnaire inputs.

	Evaluation							
Human	0	1	5	5	6	3	0	Technical
Isolating	0	0	0	5	6	7	2	Connective
Pleasant	4	6	7	3	0	0	0	Unpleasant
Inventive	2	4	6	6	1	1	0	Conventional
Simple	2	6	3	7	2	0	0	Complicated
Professional	1	10	7	1	1	0	0	Unprofessional
Ugly	0	1	0	4	8	4	3	Attractive
Practical	2	9	6	0	2	1	0	Impractical
Likeable	4	9	5	2	0	0	0	Disagreeable
Cumbersome	0	0	3	7	3	6	1	Straightforward
Stylish	1	9	6	3	1	0	0	Tacky
Predictable	1	3	7	6	1	1	1	Unpredictable
Cheap	1	2	3	7	4	0	2	Premium
Alienating	0	0	1	7	5	6	1	Integrating
Brings me closer to people	0	2	3	5	4	2	4	Seperates me from people
Unpresentable	0	0	0	2	3	10	5	Presentable
Rejecting	0	0	0	5	10	3	2	Invinting
Unimaginative	0	0	0	3	4	10	3	Creative
Good	5	11	3	1	0	0	0	Bad
Confusing	0	0	1	6	6	4	3	Clearly structured
Repelling	0	0	0	8	8	3	1	Appealing
Bold	0	2	7	8	2	1	0	Cautious
Innovative	3	8	7	2	0	0	0	Conservative
Dull	0	1	1	3	4	9	2	Captivating
Undemanding	1	1	2	3	8	3	2	Challenging
Motivating	3	6	7	2	2	0	0	Discouraging
Novel	0	7	4	8	1	0	0	Ordinary
Unruly	0	0	0	4	3	12	1	Managebale

References

1. Niinimäki, K.; Peters, G.; Dahlbo, H.; Perry, P.; Rissanen, T.; Gwilt, A. The environmental price of fast fashion. *Nat. Rev. Earth Environ.* **2020**, *1*, 189–200. [CrossRef]
2. Alves, L.; Cruz, E.F.; Lopes, S.I.; Faria, P.M.; da Cruz, A.M.R. Towards circular economy in the textiles and clothing value chain through blockchain technology and IoT: A review. *Waste Manag. Res.* **2022**, *40*, 3–23. [CrossRef]
3. Fletcher, K. *Sustainable Fashion and Textiles*; Routledge: London, UK, 2014; p. 51.
4. Jacometti, V. Circular Economy and Waste in the Fashion Industry. *Laws* **2019**, *8*, 27. [CrossRef]
5. Muñoz-Torres, M.J.; Fernández-Izquierdo, M.Á.; Rivera-Lirio, J.M.; Ferrero-Ferrero, I.; Escrig-Olmedo, E. Sustainable supply chain management in a global context: A consistency analysis in the textile industry between environmental management practices at company level and sectoral and global environmental challenges. *Environ. Dev. Sustain.* **2020**, *23*, 3883–3916. [CrossRef]
6. da Cruz, A.M.R.; Santos, F.; Mendes, P.; Cruz, E.F. Blockchain-based Traceability of Carbon Footprint: A Solidity Smart Contract for Ethereum. In Proceedings of the 22nd International Conference on Enterprise Information Systems (ICEIS), SciTePress, Online, 5–7 May 2020; Volume 2, pp. 258–268.
7. Limata, P. *Speculating on the Application of Blockchains in the Circular Economy;* CERBE Center for Relationship Banking and Economics: Roma, Italy, 2019.
8. Manshoven, S.; Christis, M.; Vercalsteren, A.; Arnold, M.; Nicolau, M.; Lafond, E.; Mortensen, L.; Coscieme, L. *Textiles and the Environment in a Circular Economy*; Eionet Report—ETC/CE 2022/2; European Environment Agency—European Topic Centre on Waste and Materials in a Green Economy: Copenhagen, Denmark, 2019.
9. Chou, Y.K. *Actionable Gamification: Beyond Points, Badges, and Leaderboards*; Octalysis Media: Sheridan, WY, USA, 2019; pp. 1–491. Available online: http://xxx.lanl.gov/abs/arXiv:1011.1669v3 (accessed on 11 October 2022).
10. Deterding, S.; Dixon, D.; Khaled, R.; Nacke, L. From Game Design Elements to Gamefulness: Defining "Gamification". In Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments, Tampere, Finland, 28–30 September 2011; ACM: New York, NY, USA, 2011; pp. 9–15. [CrossRef]
11. Alves, L.; Cruz, E.F.; da Cruz, A.R. Tracing Sustainability Indicators in the Textile and Clothing Value Chain using Blockchain Technology. In Proceedings of the 2022 17th Iberian Conference on Information Systems and Technologies (CISTI), Madrid, Spain, 22–25 June 2022; pp. 1–7. [CrossRef]
12. Briones, A.G.; Chamoso, P.; Rivas, A.; Rodríguez, S.; De La Prieta, F.; Prieto, J.; Corchado, J.M. Use of gamification techniques to encourage garbage recycling. A smart city approach. *Commun. Comput. Inf. Sci.* **2018**, *877*, 674–685. [CrossRef]
13. Groh, F. Gamification: State of the Art Definition and Utilization. In Proceedings of the 4th Seminar on Research Trends in Media Informatics (RTMI'12), Ulm, Germany, 14 February 2012; pp. 39–46.
14. Sailer, M.; Hense, J.U.; Mayr, S.K.; Mandl, H. How gamification motivates: An experimental study of the effects of specific game design elements on psychological need satisfaction. *Comput. Hum. Behav.* **2017**, *69*, 371–380. [CrossRef]
15. Ryan, R.M.; Deci, E.L. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *Am. Psychol.* **2000**, *55*, 68–78. [CrossRef] [PubMed]
16. Vansteenkiste, M.; Niemiec, C.P.; Soenens, B. The development of the five mini-theories of self-determination theory: An historical overview, emerging trends, and future directions. In *The Decade Ahead: Theoretical Perspectives on Motivation and Achievement (Advances in Motivation and Achievement, Vol. 16 Part A)*; Urdan, T., Karabenick, S., Eds.; Emerald Group Publishing Limited: Bingley, UK, 2010; pp. 105–165. [CrossRef]
17. Deterding, S. The Lens of Intrinsic Skill Atoms: A Method for Gameful Design. *Human Computer Interact.* **2015**, *30*, 294–335. [CrossRef]
18. Nor, R.M.N.; Azhar, N.A. Applying Green Gamification to Support Green Campus Initiatives in Reducing Carbon Emissions Romiza. *J. Comput. Res. Innov.* **2017**, *2*, 1–6.
19. Hamberg, L.; Hilding, P.; Källbom, A. *Eco-Gamification of the Swedish Recycling System: The Pantarevir Game;* Uppsala Universitet: Uppsala, Sweden, 2016.
20. Nel, V.L. Exploring Gamification in the South African Fashion Retail Industry. Ph.D. Thesis, The North-West University, Potchefstroom, South Africa, 2022.
21. Herzig, P.; Ameling, M.; Schill, A. A generic platform for enterprise gamification. In Proceedings of the 2012 Joint Working Conference on Software Architecture and 6th European Conference on Software Architecture, WICSA/ECSA, Helsinki, Finland, 20–24 August 2012; pp. 219–223. [CrossRef]
22. Jipa, G.; Marin, I. Enterprise gamification in business to consumer (B2C) engagement model. In Proceedings of the 8th International Management Conference, Bucharest, Romania, 6–7 November 2014; pp. 489–496.
23. Semuels, A. Online Shopping Is Making Us Accumulate More Garbage—The Atlantic. 2018. Available online: https://hyroglf.com/online-shopping-is-making-us-accumulate-more-garbage/?mode=list (accessed on 11 October 2022).
24. Green Story Inc.; Babel, N.; Toma, A.; Sivanandan, A. Comparative Life Cycle Assessment (LCA) of Second-Hand vs. New Clothing Prepared for ThredUP. 2019. Available online: https://cf-assets-tup.thredup.com/about/pwa/thredUP-Clothing-Lifecycle-Study.pdf (accessed on 12 October 2022).
25. Exchange, T. Preferred Fiber and Materials Market Report. 2021. Available online: https://textileexchange.org/app/uploads/2021/08/Textile-Exchange_Preferred-Fiber-and-Materials-Market-Report_2021.pdf (accessed on 12 October 2022).

26. WRAP. Valuing Our Clothes: The Cost of UK Fashion. 2017. Available online: https://wrap.org.uk/resources/report/valuing-our-clothes-cost-uk-fashion (accessed on 12 October 2022).
27. Roos, S.; Sandin, G.; Zamani, B.; Peters, G. *Environmental Assessment of Swedish Fashion Consumption. Five Garments—Sustainable Futures;* Technical Report June; Mistra Future Fashion Consortium: Gothenburg, Sweden, 2015. [CrossRef]
28. Weideli, D. *Environmental Analysis of US Online Shopping;* MIT Center for Transportation & Logistics: Cambridge, MA, USA, 2019; pp. 1–7.
29. OnePoll Panel: An Overview. Available online: https://panel.onepoll.com (accessed on 12 October 2022).
30. Golden, J.S.; Subramanian, V.; Irizarri, G.M.A.U.; White, P.; Meier, F. Energy and carbon impact from residential laundry in the United States. *J. Integr. Environ. Sci.* **2010**, *7*, 53–73. [CrossRef]
31. Pakula, C.; Stamminger, R. Electricity and water consumption for laundry washing by washing machine worldwide. *Energy Effic.* **2010**, *3*, 365–382. [CrossRef]
32. Statistics Brain. *Consumer Spending Statistics;* U.S. Bureau of Economic Analysis (BEA): Annapolis, MY, USA, 2017.
33. Laitala, K.; Grimstad Klepp, I.; Henry, B. *Use Phase of Apparel: A Literature Review for Life Cycle Assessment with Focus on Wool;* SIFO: Oslo, Norway, 2018; p. 167. [CrossRef]
34. Gustafsson, A.; Katzeff, C.; Bang, M. Evaluation of a pervasive game for domestic energy engagement among teenagers. *Comput. Entertain.* **2009**, *7*, 1–19. [CrossRef]
35. Kok, A. The Circularity Game: Improving the Circularity Deck through Gamification. Master's Thesis, Delft University of Technology, Delft, The Netherlands, 2020.
36. Cardoso, B.; Ribeiro, M.; Prandi, C.; Nunes, N. Gamification and engagement of tourists and residents in public transportation exploiting location-based technologies. In Proceedings of the TRA2020, the 8th Transport Research Arena: Rethinking Transport towards Clean and Inclusive Mobility, Helsinki, Finland, 27–30 April 2020; pp. 1–9. Available online: http://xxx.lanl.gov/abs/2006.16077 (accessed on 11 October 2022).
37. Kazhamiakin, R.; Loria, E.; Marconi, A.; Scanagatta, M. A Gamification Platform to Analyze and Influence Citizens' Daily Transportation Choices. *IEEE Trans. Intell. Transp. Syst.* **2021**, *22*, 2153–2167. [CrossRef]
38. Tondello, G.F.; Kappen, D.L.; Ganaba, M.; Nacke, L.E. Gameful Design Heuristics: A Gamification Inspection Tool. In Proceedings of the Human-Computer Interaction. Perspectives on Design, Orlando, FL, USA, 26–31 July 2019; Kurosu, M., Ed.; Springer International Publishing: Cham, Switzerland, 2019; pp. 224–244. [CrossRef]
39. Kazhamiakin, R.; Marconi, A.; Perillo, M.; Pistore, M.; Valetto, G.; Piras, L.; Avesani, F.; Perri, N. Using gamification to incentivize sustainable urban mobility. In Proceedings of the 2015 IEEE First International Smart Cities Conference (ISC2), Guadalajara, Mexico, 25–28 October 2015; pp. 1–6. [CrossRef]
40. Mora, A.; Riera, D.; González, C.; Arnedo-Moreno, J. Gamification: A systematic review of design frameworks. *J. Comput. High. Educ.* **2017**, *29*, 516–548. [CrossRef]
41. Tondello, G.F.; Wehbe, R.R.; Diamond, L.; Busch, M.; Marczewski, A.; Nacke, L.E. The Gamification User Types Hexad Scale. In Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play, Austin, TX, USA, 16–19 October 2016; pp. 229–243. [CrossRef]
42. Kappen, D.L.; Nacke, L.E. The kaleidoscope of effective gamification. In Proceedings of the First International Conference on Gameful Design, Research, and Applications, Toronto, ON, Canada, 2–4 October 2013; pp. 119–122. [CrossRef]
43. Nicholson, S. A RECIPE for Meaningful Gamification. In *Gamification in Education and Business*; Springer International Publishing: Cham, Switzerland, 2015; pp. 1–20. [CrossRef]
44. Ryan, R.M.; Deci, E.L. Intrinsic and Extrinsic Motivations: Classic Definitions and New Directions. *Contemp. Educ. Psychol.* **2000**, *25*, 54–67. [CrossRef] [PubMed]
45. Hamari, J.; Huotari, K.; Tolvanen, J. Gamification and economics. *Gameful World Approaches Issues Appl.* **2015**, *139*, 15.
46. Deci, E.L.; Eghrari, H.; Patrick, B.C.; Leone, D.R. Facilitating Internalization: The Self-Determination Theory Perspective. *J. Personal.* **1994**, *62*, 119–142. [CrossRef] [PubMed]
47. Heintz, S.; Law, E.L.C. Evaluating Design Elements for Digital Educational Games on Programming: A Pilot Study. In Proceedings of the 26th Annual BCS Interaction Specialist Group Conference on People and Computers, Birmingham, UK, 12–14 September 2012; BCS Learning & Development Ltd.: Swindon, UK, 2012; pp. 245–250.
48. Hamari, J.; Eranti, V. Framework for designing and evaluating game achievements. In Proceedings of the DiGRA 2011 Conference: Think Design Play, Hilversum, The Netherlands, 14–17 September 2011.
49. Boucher, J.; Friot, D. *Primary Microplastics in the Oceans: A Global Evaluation of Sources*; Iucn: Gland, Switzerland, 2017; Volume 10.
50. Kirchherr, J.; Reike, D.; Hekkert, M. Conceptualizing the circular economy: An analysis of 114 definitions. *Resour. Conserv. Recycl.* **2017**, *127*, 221–232. [CrossRef]
51. Wong, J.K.W.; Zhou, J. Enhancing environmental sustainability over building life cycles through green BIM: A review. *Autom. Constr.* **2015**, *57*, 156–165. [CrossRef]
52. *ISO 9241-11:2018*; Ergonomics of Human-System Interaction—Part 11: Usability: Definitions and Concepts. International Organization for Standardization: Geneva, Switzerland, 2018.

53. Kocabalil, A.B.; Laranjo, L.; Coiera, E. Measuring User Experience in Conversational Interfaces: A Comparison of Six Questionnaires. In Proceedings of the 32nd International BCS Human Computer Interaction Conference, HCI 2018, Belfast, UK, 4–6 July 2018; pp. 1–12. [CrossRef]
54. Hassenzahl, M.; Burmester, M.; Koller, F. AttrakDiff: A questionnaire to measure perceived hedonic and pragmatic quality. In Proceedings of the Mensch & Computer, Hamburg, Germany, 8–11 September 2003; Springer: Berlin/Heidelberg, Germany, 2003; Volume 57, pp. 187–196.