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Digital solutions for engaging end-consumers in the circular economy of the textile and clothing value chain - A systematic review

Estrela Ferreira Cruz [a,b,*], A.M. Rosado da Cruz [a,b,**]

[a] IPVC - Instituto Politécnico de Viana do Castelo, 4900-347, Viana do Castelo, Portugal
[b] Algoritmi Research Centre, Escola de Engenharia, Universidade do Minho, 4800-058, Guimarães, Portugal

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ABSTRACT

The way each person dresses has been considered a cultural manifestation and a portrait of societies, where each one expresses their habits, customs and values. The improvement in living standards, especially in developed countries, accompanied by the emergence of Fast fashion, has led to an exaggerated increase in the consumption of clothing products. This increase has a growing impact on the environment, not only in soil erosion and water consumption, due to the production of fibers such as cotton, linen, and others, but also due to the use of chemical products in the manufacturing processes of these products. The increase in consumption and the reduction in the useful lifetime of garments has led to a large increase in textile waste, which often ends up in undifferentiated garbage. One of the ways to mitigate the problem is to embark on the circular economy. This requires the involvement of all actors in the value chain, including especially the end-consumer, as this is the main responsible for closing the cycle of the economy, by sending end-of-life textile products for recycling. In this article, a systematic review on digital solutions for involving the end-consumer in the circular economy of the Textile and Clothing value chain is made, not only in closing the cycle, sending end-of-life textile products for recycling, but also in extending the useful lifetime of their garments, and in the implementation of good practices in use, maintenance and disposal of their garments.

1. Introduction

The Textile & Clothing (T&C) industrial sector is one of the largest and one of the most polluting in the world, strongly contributing to the increase in greenhouse gases (GHG) in the atmosphere (Alves et al., 2022a). The world population is consuming more clothing products from day to day, and at the same time, are keeping the clothes for less time. According to a study by McKinsey & Company,[1] between 2000 and 2014, the average number of clothes purchased, per capita, increased 60 percent. This is due, in part, to the reduction in production costs and the rationalization of supply chains, which caused the price of clothing to rise less than all other products, but also to the reduction in production times, which allowed garments' manufacturers to offer new collections more frequently. The number of collections has more than doubled, among all European garments' companies, from two a year in 2000 to about five a year in 2011, on average.

In addition to the damage caused to the environment for the production of clothes, it is necessary to deal with the clothes that are no longer used (waste). The most promising solution is transitioning from the take-make-use-dispose linear economic model (fiber cultivation - clothing production - wear - waste) to the circular economy model (Alves et al., 2022b). The circular economy is a production and consumption model that seeks to dissociate economic activity from the extraction of raw materials and the production of waste and, is focused on connecting the two extremes of the linear model, transforming the waste into new resources or raw materials (Alves et al., 2022b). The circular economy tries, at the same time, to extend the useful lifetime of garments as much as possible, based on the existence of maintenance services and the implementation of good practices by the consumer.

The main characteristics of a circular economy model are the extension of the useful lifespan of products and materials, through their reuse, repair and re-manufacturing; sustainable production, by reengineering production processes so that the design phase of products is made with a focus also on eliminating waste and pollution and reducing

* Corresponding author. IPVC - Instituto Politécnico de Viana do Castelo, 4900-347, Viana do Castelo, Portugal.
** Corresponding author. IPVC - Instituto Politécnico de Viana do Castelo, 4900-347, Viana do Castelo, Portugal.
E-mail addresses: estrela.cruz@estg.ipvc.pt (E.F. Cruz), miguel.cruz@estg.ipvc.pt (A.M. Rosado da Cruz).

[1] https://www.mckinsey.com/capabilities/sustainability/our-insights/style-thats-sustainable-a-new-fast-fashion-formula.

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resource consumption, and a recycle phase is set for creating new raw materials from used products; conscious consumption, and an increase in society's awareness for sustainable choices and waste reduction; good practices by the end-consumers during the use and disposal phases of the products, thus prolonging the lifespan of products, repairing, restoring and, ultimately, recycling every product.

For the circular economy to become a reality, the participation of all stakeholders involved is required (Alves et al., 2022b, 2023):

- Companies designing and manufacturing clothes and intermediate materials in the value chain. Creation of a new business model which could include the use of recycled fibers, etc.
- National and local governments. These need to create laws, regulations, inspections and incentives for the creation of companies for the collection and treatment of recycled materials, etc.
- Recycling companies, responsible for collecting and treating the collected material. Recycling companies are needed for separating the fibers and creating new fibers, etc.
- Clothing repair and maintenance companies need to exist in greater numbers. Clothing repair should become a normal activity during the useful lifespan of a garment.
- End consumers who, in addition to reusing/recycling clothing may influence the others stakeholders.

Citizens/end-consumers can influence companies by choosing to buy more sustainable clothing, and influence local and national governments through manifestations and even when exercising their right to vote.

The lack of consumer engagement can be an obstacle to the transition to the circular economy and to the implementation of more sustainable business models (Tunn et al., 2021). It is therefore essential to engage citizens in the circular economy. And, for that engagement, digital solutions may be of help.

Understanding how digital technologies can be used to engage consumers in the circular economy of the T&C value chain is the main goal of this article. Gamification is being used to encourage sustainable practices and raise awareness of sustainability issues in areas such as reducing energy consumption (Gustafsson et al., 2010), recycling (Helmefalk et al., 2020), using sustainable transport (Cardoso et al., 2020) among others. Recommender systems have also been used to engage in sustainability in several areas, such as smart cities (Anthony Jnr, 2021), e-tourism (Khan et al., 2021) and others. Digital marketing can play an important role in bringing sustainability intentions and beliefs closer to actions carried out in this regard (TuLe Dong, 2010).

In this article, we present a systematic literature review on digital consumer/citizen engagement strategies/tools in sustainability and circular economy in the T&C value chain.

This article is structured as follows. The next section discloses the research questions we are looking to answer in this work, and presents the research process and methods for selecting reviewed materials. For engaging end-consumers in the circular economy of the T&C value chain, a set of consumer engagement strategies, and of digital solutions for implementing those strategies, have been identified in the literature. Section 4 presents those strategies and solutions. Then, section 5 presents the main results from the systematically reviewed literature and analyzes these results at the light of the identified engagement strategies and the solutions proposed by the reviewed sources. In section 6 a brief discussion about the results found is made. Section 7 extracts conclusions and answers the posed research questions.

2. Research methodology

This article systematically reviews the state-of-the-art literature on digital solutions for engaging the end-consumers in the Circular Economy of the Textile and Clothing Value Chain. The research methodology used for this study follows the protocol defined in (Page et al., 2021). The next subsection presents the research questions, and subsection 2.2 specifies the search strategy (databases, search query, inclusion/exclusion criteria) for the review. The full screening method is depicted in Fig. 1.

2.1. Research questions

This article's main contributions are: Identification of strategies for engaging the end-consumer in the CE of the T&C value chain, and analysis of existing digital solutions for implementing the identified strategies, mapping the main solutions for each type of strategy, and pointing out ways of improving the solutions for better performing in the implementation of the customer engagement strategies.

The goal of our research is to answer the following research questions, in the context of the T&C sector:

1. What are the existing digital solutions for each of the identified consumer engagement strategies?
2. What solutions better answer to each of the identified strategies?

2.2. Materials and methods

For answering the above research questions, a review of strategies and technologies used to engage the consumer into the CE of the T&C value chain has been made. Our research was conducted between March and June 2023. The articles for the systematic review have been obtained between the days 20 and 22 of March 2023.

The following generic search query has been defined for primarily selecting the articles to review: ((consumer AND engagement) OR gamification OR (recommender AND system)) AND (sustainability OR (circular AND economy)) AND (apparel OR garment OR textile OR clothing OR fashion).

This query has been cast on Scopus,[2] and on Web of Science, WoS,[3] having been obtained a total of 121 results.

After removing duplicates, articles have been further selected by screening through title and abstract, between 22 and 31 of march 2023. And, further analysis by reading the previously selected articles has been made between 3rd of April and 15th May. The analysis of results obtained has been made during May and June 2023. This process is depicted in the diagram in Fig. 1.

In the next section, the final selected articles are presented and analyzed.

3. Strategies for engaging the end-consumer in the circular economy

There are many consumer engagement strategies, the vast majority of which are developed at the B2B (Business to Business) and B2C (Business to Consumer) levels, and intend to engage consumers to a given brand. These strategies involve, in most cases, building consumer loyalty and encouraging consumption through promotions, special discounts, etc. B2C marketing campaigns are aimed at end consumers and try to reach a category of persons who are likely to be willing to buy their products.

For citizens to practice more sustainable actions, and get involved in the circular economy, a set of new strategies are needed, some of them at the C2B (Consumer to Business) and C2C (Consumer to Consumer) levels.

For engaging the end-consumer in the circular economy of the T&C value chain, the following strategies have been identified from (Salvioni and Almici, 2020a; European Environment Agency, 2022; Gergele Jim Doucette et al., 2022; Barlow, 2021):

[2] https://www.scopus.com/search/form.uri?display=advanced.
[3] http://www.webofscience.com/wos/.

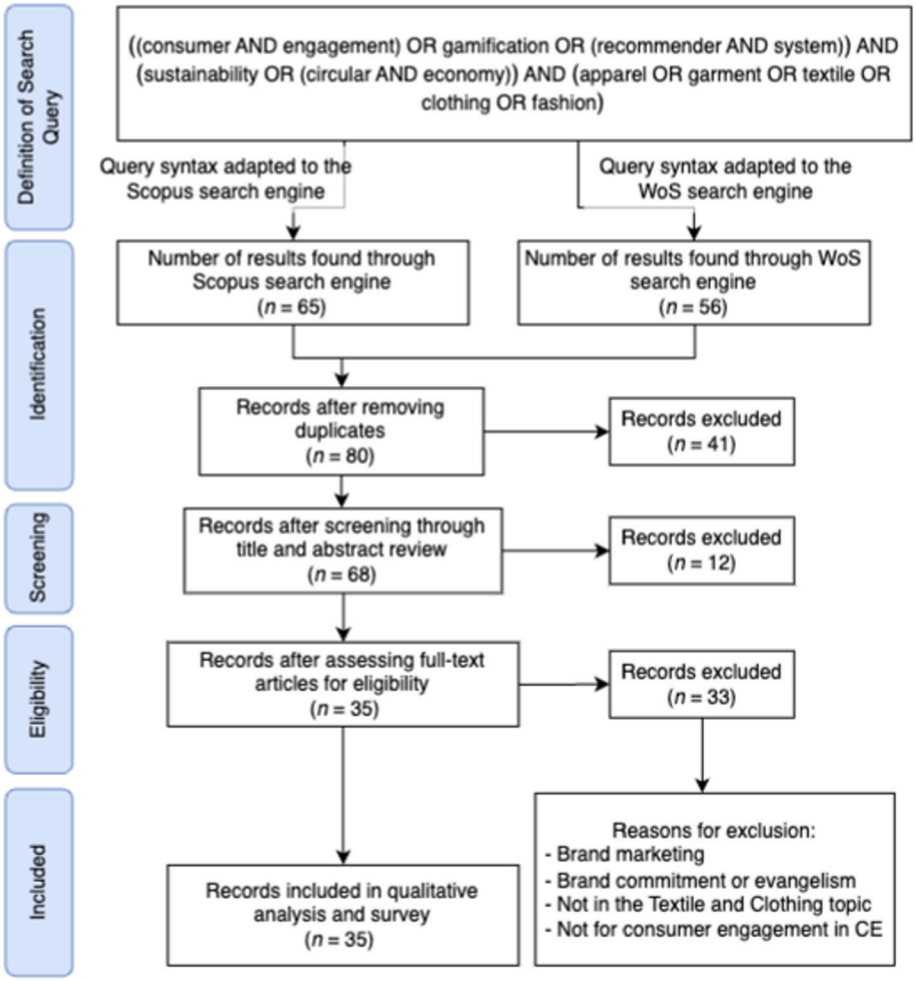

Fig. 1. Prisma Flow diagram for the process used in this Systematic Review

- Providing clear and accessible information to consumers about the production process of clothes and their impact on the environment, and about social and ethical practices of the involved companies. This increases the process' transparency and product information and creates in the consumer a sense of trust. This can be done through educational materials and awareness campaigns, and also through labels and certifications that identify circular products and their environmental impact.
- Promote the production and purchase of durable and repairable products that are designed to have a long useful lifetime. This may involve new legislation with incentives for companies that adopt these practices and the promotion of brands and products that are durable and repairable.
- Promote clothes repair, by the end-consumers, aiming to reduce waste and prolonging garments lifespan. This may be incentivized through the implementation of reward programs for consumers who adopt circular economy practices, such as repairing damaged clothes, buying or selling used clothes, participating in recycling programs or using sharing services.
- Promote a shareable economy, where products are shared or rented, and consumers have access to products when they need them, rather than buying and owning them individually. This promotes an use-oriented economic model, focused on the use of garments, instead a product-oriented one, based on buying products.
- Facilitate product recovery and recycling, through adequate collection systems and infrastructure.
- Promote consumer-centered design, by engaging consumers in the product design process. This can be made by enabling consumers' feedback and suggestions about their needs and preferences. This may help consumers feel more connected to their garments, treating them with more care and repairing them when necessary, extending their lifespan.
- Provide ongoing education and engagement opportunities for consumers through events, workshops, online platforms and social media. This helps keep consumers informed, aware and engaged with the circular economy, encouraging the adoption of sustainable practices in their daily lives.

4. Solutions for implementing the end-consumer engagement strategies

In this section the end-consumer engagement solutions are organized in four groups: Social and Sustainable Marketing, used to share and spread ideas about Sustainability and sustainable actions; Recommender systems, basically to help consumers manage the large volume of information, directing them towards sustainability; Non-gamified Applications, mainly applications that offer transparency so that the consumers can trust the information they receives; and Gamified Applications, to create gamified experiences to involve end-consumer in sustainability and to practice more environmentally friendly actions.

4.1. Social and Sustainable Marketing

Social Marketing may be defined as a marketing strategy that promotes an "effective, efficient, equitable, fair and sustained" social transformation, influencing citizens to change their behavior for the benefit of society as a whole, and relegating personal profit or individual good to the background (Saunders et al., 2015). Like eg. encourage citizens to engage in ecological or sustainable practices.

Social Marketing is being used by many brands in marketing campaigns. In (Calvo-Porral, 2019), two cases of social marketing campaigns are highlighted, namely the one of the clothing brand Patagonia entitled "Don't buy this Jacket", where Patagonia's customers are advised to make the most of each product purchased in Patagonia and to reduce unnecessary consumption; and, the social marketing campaign used by a bakery entitled "Baked before sunrise; donated after sunset", informing their customers that all unsold bread will be donated after hours, thus reducing food waste and helping to preserve natural resources.

The United Nations defines sustainability as meeting the needs of the present without compromising the ability of future generations to meet their own needs. Sustainability presupposes, therefore, that some resources are finite and must be used consciously. Sustainability is based on a balance between three main aspects: economic, social and environmental (Cruz and Cruz, 2020). So, sustainable marketing is a concept that integrates ecological, social, and economical aspects in the development of marketing strategies (Quoquab et al., 2020).

According to the study reported in (Peterson et al., 2021), with regard to citizen involvement in sustainable business, consumers especially value the role of business in terms of "offering benevolence in society, protecting nature, and playing fair in the competition of the marketplace".

A Social Sustainable marketing strategy must be supported, in a transparent way, by a real change in the business model (Salvioni and Almici, 2020b). To use sustainability marketing strategies the business has to be sustainable, otherwise it can be considered "greenwashing".

4.2. Recommender systems

People are shopping more and more online. Not only on official brand sites but also on multi-brand sites. In the case of online purchases, recommendation systems are often used. Recommender systems help the consumer to filter the large volume of information and show, in a personalized way, only the most relevant (Isinkaye et al., 2015). Recommender systems use efficient and accurate recommendation techniques in order to provide relevant and reliable recommendations to users. A Recommender system has the ability to provide personalized content and services to individuals based on knowledge about their preferences and previous behavior (Adomavicius and Alexander, 2005).

With the increase in online shopping, many companies have equipped their websites with Recommender systems so, this systems have become a very powerful way to influence the consumer.

Recommender systems are useful for both the service provider and the user, and nowadays they are used to recommend music (songs), movies, food, books, clothes, etc. (Deldjoo et al., 2020).

This strategy can be effectively used to challenge and engage citizens (consumers) in the context of sustainability.

4.3. Non-gamified applications

In order to consumers to get involved and choose to integrate sustainable clothing projects, and even pay more for it, they need to feel safe and have knowledge about what goes into creating the clothes they intend to buy. To support this, many traceability platforms have emerged, allowing to know the entire history of the product from the creation of the fibers until it reaches the end-consumer. The main objective of these platforms is to make the entire production process more transparent. and to earn consumer trust.

Traceability platforms make it possible to know who, when, where and how all stages of product production were carried out, thus providing transparency over the production process and the entire value chain (Cruz et al., 2019). Traceability can also help ensuring the authenticity of a product (garment) and thus prevent counterfeiting.

4.4. Gamified applications

The use of gamification techniques that involve citizens and brands/companies involved in the value chain can be a strategy to promote and increase their participation and involvement in the circular economy.

Gamification is a term that represents the "application of game principles and design elements in non-game contexts" in order to improve the user experience and thus increase their engagement (Deterding et al., 2011). Gamification involves fun, rewards, competition, encouragement, challenges and motivation.[4] According to Ashok Kamal[5], games are one of the most effective tools for leveraging technology and engaging the consumer.

"Eco-gamification" or "green gamification" is a concept specifically aimed at a sustainable environment centered on ecological behaviours. Basically, the intention is to apply the concept of gamification to sustainability, in order to make participation more fun, rewarding and gratifying (Nor and Azhar, 2017). Thus, the so-called "green games" promote environmentally sustainable behavior, challenging the player by proposing real-life tasks that are beneficial in one or more issues, aiming to reduce the global impact on the planet.

5. Results

This literature review research aimed to find digital solutions to engage consumers in the circular economy. This section details information on reviewed articles.

The way each person dresses thyself is a cultural manifestation and a portrait of society, and is a function of those values that forms a person's self-identity. This way, a move towards a more environmentally and socially sustainable society is an important move towards more pro-environmental and socially just self-identities. Following this line of though, several of the studied articles conclude that for increasing environmental and social sustainability, in the T&C sector, consumers must adapt their self-identities towards more informed and sustainability-demanding ones.

Fashion consumers often overconsume and discard functional clothing just for reasons of style and taste (Lisa et al., 2020). To encourage consumers to adopt a sustainable fashion model, it is important to understand their perceptions of garment value and what factors lead to the categorization of items as suitable for practices such as extending their lifespan or final disposal.

In (Lisa et al., 2020), the authors make this analysis, and examine the behavioural intentions for garment life extension practices of young, urban, South Koreans, and conclude that the intention of extending the lifespan of used garment is influenced overall by garment damage and perceived quality, as well as by garment type in some scenarios.

In (Gręboszc-Krawczyk and Siuda, 2019), the authors study the willingness of young consumers from Poland, France and Spain to participate in recycling campaigns from clothing companies. In the study, conducted in the fourth quarter of 2017, young people received discount vouchers when returning no longer used clothing, this way contributing to the circular economy. Then, from the clothes received, the brands separated the ones that were still useable to donate, and the rest was sent for recycling (Gręboszc-Krawczyk and Siuda, 2019). Clothes sent for

[4] (https://www.greenbiz.com/article/using-green-gamification-fun-and-fame).

[5] (https://www.greenbiz.com/article/not-all-distant-future-green-gamification).

recycling went through several activities, such as removing labels, buttons, etc., and discoloration and cutting into small parts, before being able to be used as raw material for creating new yarn, thus closing the loop. According to the authors, in order to be successful, these campaigns must be accompanied by publicity and marketing campaigns, so that the involved clothing brands' image from the consumers viewpoint is positively affected, and they become more aware of the importance of recycling textiles. The authors also conclude that there is a discrepancy between the intention of being more sustainable and what actually happens in practice (Gręboszc-Krawczyk and Siuda, 2019).

In (Rungruangjit and Charoenpornpanichkul, 2022), the authors talk about the so called "Micro-influencers" as a powerful way of promoting brands and other values, such as sustainability values. Instagram seems to be the preferred way for influencers to promote those brands and values. The results revealed that what encourages consumer-influencer engagement is, in the first place, the timeliness of the content, followed by its novelty, comprehensibility, reliability, interest and authenticity (Rungruangjit and Charoenpornpanichkul, 2022).

Accepting second-hand clothes buying, and clothes renting, is also a change demand on consumers habits. The article (Charnley et al., 2022) concludes that inconvenience, as the lack of immediate availability or the accessibility and efforts needed to obtain second hand clothes, are the main identified barriers to consumer acceptance of used clothes buying and clothes renting. Other barriers are concerns about hygiene, or the ability of clothes rental provider to ensure clothes cleanliness; trust issues, as the lack of information on previous usage, defects, quality or motives to sell; price transparency issues, as how is the price set.

The authors in (Charnley et al., 2022) also found that social media is an efficient tool amongst youngsters to raise a brand's awareness toward sustainability, but that digital tools alone cannot significantly change consumers buying behaviour. Authors end up concluding that a mobile app integrated with gamification techniques would be a great contribute to engage consumers with sustainable consumption.

Zheng Shen presents a study about the relationship between comments about sustainability on social media and consumers behavior (Shen, 2023). The study concludes that sustainability-related comments have a positive impact on consumer attitudes.

In (Man Yuen et al., 2021), authors carried out a study on how tweets about sustainability, made by clothing brands, influence consumer behavior. The authors conclude that tweets about sustainability alert consumers and facilitate their engagement in sustainability. The study also concludes that tweets about social sustainability have more influence than tweets about environmental sustainability. Furthermore, consumers are more easily influenced by tweets from luxury brands than mass fashion brands.

In (Johnstone and Lindh, 2022) and (McKeown and Shearer, 2019) the authors focus on the ability that influencers and celebrities may have in influencing their followers on social networks to adopt more sustainable attitudes and consume more sustainable products.

The authors in (Bocken and Short, 2016) propose 'sufficiency' as a driver of business model innovation for sustainability. A business model driven by sufficiency aims to moderate resources consumption reducing demand through consumer education and engagement, making products last longer, satisfying 'needs' rather than promoting 'wants' and fast-fashion. The article studies how companies might use sufficiency as a driver for innovation.

In (Elf and Werner, 2022), from a study on how Small and Medium Enterprises (MSMEs) in the fashion industry implement and participate in the circular economy (CE), the authors concluded that smaller companies are more agile and dynamic, being able to easily extend, or adapt, their business model, by implementing close interactions with their customers, in attempts to adopt CE practices.

In (Abner and Baytar, 2019) the authors explore the use of an App with environmental impact index calculation to study its benefit when used by students in a project work. The authors conclude that industry-related apps help students find the real environmental impact of materials used in clothes, and also in the final apparel product, and that this promotes their knowledge and interest in the real environmental impact of the products they buy or that they will make in the future, increasing their engagement with sustainability.

Article (Kozlowski et al., 2016) proposes the creation of a new, more sustainable, business model, involving the creation of more sustainable products, through sustainable management of the supply chain; creation of more sustainable designs; and, the involvement of the end consumer. A more sustainable design can involve the creation of products that can influence the end-consumer toward more sustainable behavior, reducing consumption and its environmental impact.

In article (Petreca et al., 2022), the authors explore how emerging creative technology and interaction design might support a shift in the role of citizens, by engaging in the Circular Economy. The study showed that citizens aware of their responsibility within consumption cycles revealed concern about their lack of understanding on how to become agents of responsible consumption. Experience design, and interaction techniques for consumers to participate in circular processes, have shown that, when consumers have a more creative and informative material involvement, deeper connections can be forged between consumers and products/materials, turning citizen-consumers into custodians of materials, extending the lifespan of their products.

The authors in (Liu et al., 2022) have conducted a survey on slow-fashion versus fast-fashion and its relationship with consumer well-being. Slow-fashion involves creating products with better quality, design, sustainability, ethics and local artisan heritage. The study concludes that slow-fashion, or the manufacturing of customized clothes and the consumer's involvement in the design and creation of the garments, increases the consumer's well-being. Another conclusion shows that the classic clothing design, more discreet, which facilitates the combination of these with other clothes, and the ease of maintenance, are characteristics that prolong the use of the garment (Liu et al., 2022).

Focusing on the importance of repair services for improving the lifespan of garments, and thus reducing clothing consumption and textile waste, the authors in (McQueen et al., 2023) analyze common repair services as resources that comprise the skills, tools, priority, and perceived expense that may motivate one toward self-repair, paid and unpaid repair of clothing. The authors conclude that women are more likely to engage in self-repair, while no gender differences appeared in paid and unpaid repair. The search for self and paid repair, increases with the age increase, while unpaid repair is more likely to be used by the younger consumers. Paid repair is more likely to be used if the cost of the repair services is not perceived to be prohibitive (McQueen et al., 2023).

Collaborative economy, such as 2nd-hand clothes, and clothes sharing or swapping, is a way of extending the lifespan of the garments.

In (Camacho-Otero et al., 2020), the authors talk about good practices to reduce the carbon footprint of the fashion industry (clothing/apparel). The article focuses on "clothes swapping" and talks about the reasons why people exchange clothes. The article presents some examples carried out in Colombia. The authors present economic, environmental and social reasons that lead to this practice, and conclude that, for these initiatives to be successful, it is necessary to have commitment from the organizers, and to recruit collaborators with skills to select the appropriate garments, etc. This type of initiative can gain a good or bad reputation depending on how it is managed. In the case of Colombia, one of the factors that led people to participate in these exchanges is the fact that the indigenous community also participated. This community exchanges artifacts created manually by the indigenous community for clothing. These exchanges have to follow some rules, which have to be verified by the organizers, such as, before swapping a garment it has to be washed and it must be in good condition.

The article (Peña-Vinces et al., 2020) focuses on assessing the extent to which consumers' environmental knowledge, and their relative involvement in the collaborative economy influence responsible consumption. The article also addresses the role that technologies may play

in the collaborative economy. The study has been developed in Spain, and focuses on infant and perinatal clothing and consumers' intention to rent or share clothing. Because perinatal and infant clothing is worn for a short period of time, it generates large amounts of waste and discarded clothing. Thus, with increased consumer awareness and appropriate technology support, the second-hand perinatal and infant clothing industry is booming (Peña-Vinces et al., 2020). The study concludes that technologies play a very important role and drive the collaborative economy.

The article (Shang and Wu, 2022) talks about the impact of green morality and platform quality as an essential point for collaborative consumption. Collaborative consumption integrates commerce, sharing, lending and renting by using technology for the acquisition and distribution of resources for a fee or other type of compensation, promoting, this way, circular economy and sustainability. The study, which is based on a questionnaire made to consumers, yields results which reveal that the "green morality" and the quality of the platform are decisive for the behavior and incentive of collaborative consumption. This study deepens the relationship between the quality of the platforms created (electronic commerce), and consumption and collaborative commerce to promote sustainability.

Consumers are very important players in the T&C value chain, which is why it is necessary to encourage more sustainable practices. Thus, many of the articles focus on encouraging the consumer to be more sustainable. However, political actors also have an important role. The article (McEachern et al., 2020) focuses on more innovative policy solutions to encourage behavior change in the context of clothing consumption practices. The authors of this article suggest a set of policies and initiatives that can be put into practice in favor of sustainability. The conclusions are that individuals show signs that they intend to change but the authors were not able to conclude that these changes were actually put into practice.

The article (Dhir et al., 2021) studies the discrepancy between consumers' intention to buy more sustainable and greener products, and the practice. The authors carry out a study based on an online survey of consumers in Japan. The authors conclude that optimism and pessimism of consumers also influence the purchase. The more optimistic tend to prefer to compare more green compared to the less optimistic. However, they agree that there must be standards at label level and that this work must be developed by the government. In practice, consumers do not opt for the greener option because they do not feel that they can make a difference.

In the article (Rosa and Jorgensen, 2021), the authors conduct an online study with the aim of identifying consumers' intention to engage in sustainable practices and their intention to purchase sustainable clothing options. The study concludes that a greater intention to be sustainable influences the practice of more sustainable actions, and that, the intention to buy more sustainable products is related to more environmentally friendly attitudes. The study also concludes that family and friends associated with the ease of finding more sustainable products influence the purchase of more sustainable clothing.

In (Muposhi and Chuchu, 2022), the authors describe a study, carried out in South Africa, to identify the factors that influence the new generations (millennial generation) to have more sustainable behavior with regard to clothing. The study concludes that brands need to create clothes that are more sustainable and in line with personal style and values, allowing, in this way, a personalization and customization of sustainable fashion. It is also necessary to invest in educational campaigns to reinforce positive attitudes towards sustainable fashion. The creation of eco-labels that succinctly communicate the environmental benefits of sustainable fashion should also be encouraged.

Fashion consumption is intrinsically dependent on social identity, and for this reason, many individuals over-consume in pursuit of ideal identities, particularly in their youth, where identity development is more active. Article (McNeill and Venter, 2019) studies young females core motivations and barriers towards collaborative fashion consumption, from the point of view of self-identity and social interaction. The paper studies how young females construct a fashion identity within the social contexts of four alternative forms of consumption (renting, borrowing, swapping and purchasing second-hand). The study also examined perceived barriers to participation in these four alternative fashion consumption forms. Conclusions show that social and ethical implications of sustainable consumption behaviour are the least likely motivators towards engagement with collaborative fashion consumption models within this group. Opportunities for individual identity expression are the most sought after benefits of such engagement.

The main objective of the article (Suresh and Amritha, 2020) is to study the communication strategies of textile brands that are concerned with sustainability. One of the conclusions of the study emphasizes the importance of the message about sustainability, and associating this message with the brand's involvement in sustainability and showing transparency in this involvement.

The authors in (Kozar and Connell, 2013) report the study of the relationship between knowledge about environmental and social responsibility and the attitude of purchasing more sustainably, in the apparel and textiles industry. One of the conclusions reached out by the authors is that both knowledge and more sustainable attitudes were significant predictors of socially and environmentally responsible purchasing behavior (Kozar and Connell, 2013).

In (Zhao et al., 2019), the authors concluded that as consumers learned more about social and environmental issues, their positive attitudes toward environmentally sustainable purchasing behavior increased. Also, results of the analysis revealed that consumers' engagement with their peers on social media are important social influences that are directly associated with increased purchase intentions for sustainable clothing.

The article (Kant Hvass, 2014) studies the post-retail of garments, namely their reuse and recycling, from the fashion industry's perspective. The paper finds that the emerging organizational field of post-retail responsibility of garments offers business opportunities to fashion companies, while also requiring the assessment of existing value propositions. Two main strategies applied by fashion companies to address post-retail responsibility of their products are second hand retailing and product take-back schemes. These strategies for prolonging the lifespan of the garments, when applied by the brand owners, try to capture the resell value of their products. Three main ways of organizing the initiatives are also identified: entering a donation partnership with a charity, collaborating with an external private actor due to lack of know-how and relevant resources or running their post-retail initiatives internally.

Article (Khitous et al., 2022) reflects on the engagement of customers in Product-Service Systems (PSSs), which are oriented towards dematerializing fashion consumption by offering bundles of products and services. The work leverages the benefits customers seek when engaging with product-oriented (e.g., second-hand markets) and use-oriented (e.g., sharing, renting) PSSs in the fashion industry. Results show that customer engagement with PSSs in the fashion industry is a function of the benefits that customers expect to reach (economic, pragmatic, cognitive, personal, hedonic, and societal expectations) and their demographic characteristics (gender and age). Depending on demographic characteristics and the expected benefits, customers were found to engage with specific PSSs. For instance, women engage more easily with product-oriented PSSs (swapping or second-hand), while customers who engage with use-oriented PSSs (rental) and product-oriented PSSs (swapping) tended to be younger people.

In (De Bruyne and Verleye, 2023) the authors carried out a study on the extent to which ownership transfer, remuneration, digitization, and community scope influence consumer engagement in the sharing business model. The results suggest that consumers are more engaged with the ownership of tangible resources, i.e., second-hand markets, instead of renting or sharing, either for consumers with a low sustainability orientation and consumers with a high sustainability orientation. Local

community scope is also more engaging for consumers, rather than global community scope. The presence of professional service providers, monetary compensation and a digital platform, seems to induce more engagement, but only among consumers with a low sustainability orientation.

In (Moriuchi and Takahashi, 2022), the authors examine the relationship between online consumers' perceived value of used products and their re-purchasing intention from a secondary marketplace platform. The study focuses on the implications of trust and engagement and how these factors impact consumers' intention to re-use an online C2C (Consumer to Consumer) platform for trading second-hand clothing. The results suggest that consumers who repeat their purchase on C2C platforms are reliant on both the trustworthiness of the C2C platform and the seller. Trust in the platform matters more when sellers are selling used hedonic (for pleasure) products than utilitarian products. The question of how to use digital tools to face the challenges in the interface between the producer and the consumer is addressed in article (Carlsson et al., 2022).

There, the implementation of a traceability platform to offer transparency to all those involved in the clothing value chain, including the end-consumer, is proposed. Platforms that implement the digital twin of products offer transparency in the value chain, giving credibility to the product, and making more easy for the consumer to trust the information about the product and easily identify more sustainable products. Traceability platforms allow business partners to work together in order to create more sustainable products by optimising resources. At the same time these platforms are the basis for the transition to the circular economy.

The article (Waydel-Bendyk et al., 2020) analyzes the potential of the digital space to facilitate more Sustainable Fashion Consumption (SFC). Namely, the use of gamified social application (GSA) to influence consumer behaviour towards SFC is researched. The authors looked into various academic areas such as psychology, sociology, macro marketing and economics, to find ways to change fashion consumption through different game elements. The authors conclude that well-designed GSA has the potential to foster SFC, and that gamification can be a useful tool in raising awareness through positive reinforcement about the consequences of fashion over-consumption.

The articles (Kolstad et al., 2017) and (Kolstad et al., 2018) propose the creation of an intelligent closet where all the garments are duly labeled with an RFID (Radio Frequency IDentification) and thus track these garments. This approach allows to know when the garment leaves or enters the closet. This Proposal was extended in (Anders et al., 2018) where the created application allows garments to be sent for recycling. To do this, the authors are using a context-based recommendation system that, based on previously collected information about the use of clothing, is able to suggest garments that are "ready to recycle". This way the authors are encouraging the participation of users on the circular economy and for the environmental sustainability.

Recommender systems are an important part of online clothing sales platforms, as these systems make it possible to filter and propose the products that will be of greater interest to the consumer. Some consumers prefer to buy more sustainable products. Therefore, online sales platforms must be prepared to suggest this type of product (Nguyen et al., 2014). In this context, in (Hwangbo and Kim, 2019) the authors study the use of recommendation systems of various types to involve sustainability in consumer choice. The authors are proposing a new method to be used in recommendation systems on sustainable fashion product sales platforms that uses item and attribute session data. The proposed method combines various ASBRs (Attribute Session-Based Recommenders) and conventional CFR (Collaborative Filtering Recommender) allowing to overcome the cold-start problem without a loss of performance.

6. Discussion

In this section, an analysis and discussion of the articles selected for this study, and presented in the previous section, is made. In Table 1, the surveyed articles are put in the middle field, between actions needed for answering the strategies to promote and change to Circular Economy, identified in section 3, and the digital solutions that best answer in engaging consumers onto those strategies/actions.

From an analysis of Table 1, one can note that most of the surveyed literature focuses on social marketing through digital platforms (e.g., social networks) for implementing the end-consumer engagement strategies. Social marketing is the most used solution when the goal is to inform or educate the customer.

Non-gamified consumer apps are the main solution for inscreasing process transparency. These type of applications include applications for products' traceability, but also applications that enable the customer to be more closely involved in the product design process, for instance enabling the customer to customize a clothing product to their will or needs.

Some non-gamified apps are also used for implementing strategies for collaborative economy, such as sharing or 2nd-hand trading of garments. Nevertheless, gamified applications seem more engaging to customers in this goal.

Gamified applications are applications that use gaming elements and principles, such as points, rewards, challenges, and leader boards, for making actions towards circular economy more atractive and fun, thus better motivating and engaging users into completing those actions.

In the surveyed literature, gamified applications have been mainly used for engaging the end-consumer into the collaborative economy, namely into sharing, renting, and swapping garments in a community, or buying/selling 2nd-hand garments, for keeping in use textile pieces in good condition, prolonging their lifespan. Besides these, one article also focused the use of gamified apps for helping the user develop a more pro-environmental self-identity (cf. Table 1).

Some existing solutions also use recommender systems for helping the user buy more environmentally friendly clothing products, either new or 2nd-hand, by providing personalized recommendations based on sustainable criteria, and to sell second-hand items that they no longer use.

Typical recommender systems for buying garments gather data on garments and capture user preferences (e.g., previously bought garments on the same site), and then use a recommendation algorithm that takes into account the user's preferences and the garments attributes for providing personalized recommendations. Data gathered on garments may include sustainability attributes that may be part of the recommendation criteria, such as materials used, production methods, certifications, and sustainability ratings. This data can be collected from manufacturers, suppliers, or third-party sources that assess the sustainability aspects of clothing. User preferences on sustainability can be collected through explicit input (e.g., questionnaire) or implicit (e.g., previous purchases, previously viewed garments, feedback).

For using recommender systems in helping consumers buy more sustainable clothes and dispose of clothes they no longer use in an eco-friendly way, it is necessary to create user profiles that reflect their preferences in terms of sustainability. The recommender system may also consider sustainable criteria when making recommendations, with factors such as organic or recycled materials, fair trade or ethical production, water and energy usage, carbon footprint, certifications, etc.

For helping in educating the end-consumers towards CE and environmental sustainability, the recommendations should be accompanied with educational content and information about the sustainable criteria used.

Table 1
Mapping digital engagement solutions to the strategies/actions towards CE in the T&C value chain.

Digital Engagement Technologies / Strategies/actions for consumer engagement in T&C CE	Social Marketing through Digital Platforms	Non Gamified Consumer Apps	Gamified Consumer Apps	Recommender Systems
Buying less/buying environmen-tally or socially sustainable gar- ments/Develop a consumer's pro-environmental self-identity	(Bocken and Short, 2016; Liu et al., 2022; McEachern et al., 2020; Dhir et al., 2021; Rosa and Jorgensen, 2021; Muposhi and Chuchu, 2022; Hwangbo and Kim, 2019)	Shang and Wu (2022)	Waydel-Bendyk et al. (2020)	
Collaborative economy: 2nd-hand trading of used garments	McNeill and Venter (2019)	(Camacho-Otero et al., 2020; Peña-Vinces et al., 2020; Shang and Wu, 2022; Kant Hvass, 2014; Khitous et al., 2022; Moriuchi and Takahashi, 2022)	(Charnley et al., 2022; De Bruyne and Verleye, 2023; Kolstad et al., 2017, 2018; Anders et al., 2018)	(Kolstad et al., 2017, 2018; Anders et al., 2018)
Collaborative economy: renting, sharing, swapping garments	McNeill and Venter (2019)	(Camacho-Otero et al., 2020; Peña-Vinces et al., 2020; Shang and Wu, 2022; Kant Hvass, 2014; Khitous et al., 2022; Moriuchi and Takahashi, 2022)	Charnley et al. (2022)	
Social Marketing/Educational Activities towards sustainability and Circular Economy	(Shen, 2023; Man Yuen et al., 2021; Johnstone and Lindh, 2022; McKeown and Shearer, 2019; Zhao et al., 2019)			
Brands' Marketing and Activi-ties towards sustainability and Circular Economy	(Grębosz-Krawczyk and Siuda, 2019; Rungruangjit and Charoenpornpanichkul, 2022; Charnley et al., 2022; Dhir et al., 2021; Suresh and Amritha, 2020)			
Ease of Maintenance/Availability and price of maintenance services	Liu et al. (2022)	McQueen et al. (2023)		
Process Innovation: Involving the consumer in the Design Process	Petreca et al. (2022)	(Elf and Werner, 2022; Abner and Baytar, 2019; Kozlowski et al., 2016; Petreca et al., 2022)		
Process Innovation: Process Transparency Increase (e.g., traceability, sustainability score)	Suresh and Amritha (2020)	(Muposhi and Chuchu, 2022; Suresh and Amritha, 2020; Kozar and Connell, 2013; Carlsson et al., 2022)		

7. Conclusion

It is a fact that the population in general, especially in developed countries, is consuming too much resources, causing damage to the planet. Besides that, this consumerism is also producing too much waste. This behavior needs to change in order to become more sustainable.

A more sustainable consumption may involve consuming less, extending the life of the products, consuming more sustainable products and, at the end of a product's lifespan, sending it for recycling. Extending the life of the product can mean using it more often and sharing, donating or selling second-hand. Sending for recycling can feed the manufacturing industry of parts with recycled material as raw material, thus contributing to the circular economy.

This systematic review has analyzed the state-of-the-art literature on digital solutions for engaging the end-consumers in the Circular Economy of the Textile and Clothing Value Chain. From the analysis of results and discussion in the previous sections, we are now able to answer the research questions posed in section 2, in the context of the T&C sector.

1. What are the existing digital solutions for each of the identified consumer engagement strategies?

Existing digital solutions for engaging consumers into the circular economy of textiles & clothing include using social marketing, typically through digital social networks, to inform the consumer about good practices for sustainability and CE, or for letting them know about brand's promoted activities towards sustainability and CE (refer to Table 1).

Some of the discussed studies show that consumers sometimes intend to have a more sustainable attitude, but there is a discrepancy between the intention to be more sustainable and the practice of being so (Grębosz-Krawczyk and Siuda, 2019; McEachern et al., 2020; Dhir et al., 2021; McNeill and Venter, 2019).

Some solutions for improving the information that reaches the end-consumer, increasing process transparency, are based on traceability and certification platforms, and consumer apps for consulting the associated information. With regard to buying more sustainable garments, it is necessary to create standard labels, that are reliable and easy to interpret for all consumers, associated to traceability mechanisms, so that consumers can more easily decide to buy the most sustainable garment. It is also needed to create sustainable clothing that meets consumer expectations (Muposhi and Chuchu, 2022). The creation of clothing with a more discreet design combined with ease of maintenance leads to a longer use of the garment (Liu et al., 2022). The implementation of traceability, in order to offer transparency along the value chain of clothing items, is another need found to be fundamental for consumers to trust the brand and for them to be confident about the sustainability of the item they are buying (Ivan et al., 2016).

There are also non-gamified apps for involving the consumer in the design process, or customization, of their clothing.

For better engaging consumers into acting more sustainable, besides wanting to be sustainable, some studies suggest the use of gamified applications, which use gaming elements for keeping the consumer motivated into taking sustainable actions.

Gamified and non-gamified consumer apps are also used for engaging the consumer into the C2C collaborative economy, namely for enabling trading 2nd-hand clothes, renting garments, or sharing and swapping garments within a community of users. Studies reveal that digital technologies play a very important role in extending the lifespan of garments, as they allow sharing/donating/second-hand trading clothing, and facilitate consumer engagement in a more sustainable consumption approach (Shang and Wu, 2022; Peña-Vinces et al., 2020).

Another emerging solution for engaging consumers into taking sustainable actions and implementing the circular economy involves the use of recommender systems.

2. What solutions better answer to each of the identified strategies?

From Table 1, one can see that, while social marketing through digital platforms tries to answer all the consumer engagement strategies, with more focus on instilling greater sustainability awareness and publicize the brands' efforts towards greater sustainability, the other engagement solutions tend to have their own favorite applications.

Lack of consumer engagement hampers the transition to the circular economy and the implementation of new, more sustainable business models (Tunn et al., 2021).

Non-gamified applications are the typical technological solution for engaging the consumer into participating in the process innovation, namely by participating in the design or customization of their clothes, and by obtaining sustainability information, such as the environmental impact of an item, and basing their decisions on the sustainability information obtained, giving preference on acquiring more sustainable items. The creation of new business models, which involve the consumer in the design and construction process of the garment, can increase consumer satisfaction and thus extend the lifespan of the garments (Liu et al., 2022; Petreca et al., 2022). It is, then, necessary to create Interaction Design Platforms, allowing the consumer to be involved in the creation of the garment in an easy and friendly way.

Non-gamified applications, and also applications with gaming elements, are the best solutions, according to the surveyed literature, for engaging consumers in the collaborative economy.

Currently, and strongly driven by the pandemic, virtually every brand has an online store. There are also very successful multi-brand online stores. For these cases, recommender systems that take into account the sustainability of the garments can facilitate consumer engagement, both for new and 2-nd hand garments. However, and for these systems to be able to operate, it is necessary that the information on sustainability is available and presented in a standard and clear way. Some solutions suggest a recommender system for aiding and educating users in selecting more sustainable garments, users receive personalized suggestions that align with their sustainability preferences and values, empowering them to make more informed decisions and promoting sustainable consumption in the fashion industry.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Estrela Ferreira Cruz reports financial support was provided by Portuguese Environmental Fund. A. M. Rosado da Cruz reports financial support was provided by Portuguese Environmental Fund.

Data availability

No data was used for the research described in the article.

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