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Multi-variant e-commerce user interfaces for business sustainability

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Abstract

Consumers and their consumption-patterns play an important role in efforts to make businesses and industries more sustainable. Although, theoretical basis for business to engage customers in more sustainable consumption is still under development, data-driven personalizing in e-commerce is emerging as a potential means of supporting company's efforts. However, such analyses are lacking in the literature. The purpose of the article is to adapt the general framework that enables the delivery of multi-variant e-commerce user interfaces to shape customer engagement for sustainability. The framework has been adapted so that it can be used to shape customer engagement for sustainability, using concepts of customer engagement and business sustainability embedded in stakeholder theory. The paper has a practical contribution (empirical verification of the effectiveness of the concept) and a consequent theoretical contribution (development of a sustainability-oriented version of the framework).

Keywords: *business sustainability, e-commerce, personalization, user interface, customer engagement*

1. Introduction

Sustainable development is considered as one of most critical and urgent challenges that humanity is facing. In addition to business and government, consumers and their consumption-patterns play an important role in efforts to make businesses and industries more sustainable [14]. The sustainable consumption concept is emerging as crucial, it refers to individuals' acquisition, usage and disposal of goods and services, which consider the impact of ecological and socioeconomic conditions for current and future generations [17].

On the one hand, consumers are showing a willingness to adopt sustainable consumption behaviors [17], their interest towards sustainable solutions grows (searches for sustainable goods increasing globally by 71% since 2016 [13]), they also declare the willingness to pay more for sustainable products.

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On the other, while majority of consumers consider sustainability issues when making purchases, only 3% to 6% indicate it as their major choice driver [8]. According to research of Deloitte [12], there is a growing inclination towards sustainable lifestyles, however, a significant obstacle to the widespread adoption of sustainable practices remains the affordability and the accessibility of sustainable options. Moreover, consumers do not understand key sustainability terms and they report difficulty identifying the sustainability offers [8, 27]. This highlights the need for a more inclusive approach to ensure that sustainable choices are not confined to niche markets, and that consumers are provided with the necessary information to make choices aligned with their sustainability values.

Theoretical basis for business to engage customers in more sustainable consumption patterns are still under development. Sulkowski et al. [28], propose to move away from viewing stakeholders (and consumers are key stakeholders) as groups with separate interests that are distinct from the enterprise. In their view, the key to adapting stakeholder theory for the business sustainability is to focus on the interdependencies between stakeholders, and the enterprise should be seen as part of a network of these interdependencies. The relationship between stakeholders is then seen as a process of creating shared, sustainable value [22, 28]. Such a perspective requires going beyond simply responding to stakeholder pressures towards consciously engaging the company in creating innovative solutions to create mutual benefits for the company, society and the environment. In this context, a collaboration between business and consumers for sustainable development include customer engagement in more sustainable products development and consumption, education and awareness building for and together with customers, and collaborative initiatives for sustainable development [11, 14, 21, 28].

However, the co-engagement for sustainability depends on the motivation and readiness of both customers and the business, its scope and manner varies for different customer groups and interactively change over time. New digital technologies enable customer engagement providing new business opportunities for data-driven personalizing [7] and new ways in which customers and companies can interact, including purchase and non-purchase behavior [22]. A particular role for e-commerce is emphasised [7, 25]. On the one hand, the importance of e-commerce continues to grow with the share in total sales estimated to rise to 24.5% by 2025 [25]. On the other, Rita and Ramos [25], based on a systematic literature review, argue that sustainability issues related to e-commerce and consumer behavior have been gaining importance in recent years. There are first studies on the importance of access to information on options and effects of environmental and social sustainability in engaging customers in more sustainable choices (studies also conducted in the area of e-commerce) [25]. Still, the empirical results show that there is still not enough awareness of the potential of this channel to promote sustainable development [7]. One area where there is a lot of potential is personalizing the user interface (UI). A typical online store has one version of each page and displays it to each customer, regardless of their characteristics. However, many different versions of each page in the store can be implemented and displayed, depending on the identified characteristics and behaviors of the customers [31]. The correct grouping of customers and choice of interface can be based on Machine Learning (ML) algorithms that can support the creation of a dedicated user interface [3]. Such a solution can constantly learn and ultimately increase the efficiency of the online store due to the set objectives, including sustainability engagement.

The purpose of the article is to adapt the general framework that enables the delivery of multi-variant e-commerce user interfaces to shape customer engagement for sustainability. The current study addresses three main research questions:

RQ1. What is the role of business in engaging customers in more sustainable consumption patterns?

RQ2. Do dedicated e-commerce user interfaces affect customer behavior?

RQ3. What modifications need to be made to the general framework of ML-based multi-variant user interfaces in e-commerce so that it can be used to shape customer engagement for sustainability?

The paper describes the general framework that enables the delivery of variants of e-commerce user interfaces, and the results of its pilot implementation. It identifies the main components that should make up a comprehensive solution for delivering dedicated e-commerce user interfaces. A proposal is made to adapt the general, empirically verified framework to support the business – customers co-engagement for sustainability. A literature study was carried out to identify the role of business in engaging customers in more sustainable consumption patterns and to select the general framework that enables the delivery of multi-variant e-commerce user interfaces. An empirical research was conducted to verify whether dedicated e-commerce user interfaces affect customer behavior, in a a pilot implementation of a platform serving a multi-variant UI in an online shop in the fashion industry.

Developed framework is potentially potent tool both in the context of fostering informed and purposeful decisions by consumers who want to base consumption choices on personal, moral beliefs and values, and for increasing awareness of and interest in a particular social cause or even supporting the willingness to take action for that cause (whether in conjunction with a purchase or not).

2. Literature review

2.1. Customer engagement for sustainability

Prior studies generally agree that customer engagement (CE) is a psychological state that occurs by interactive, co-creative experiences of subject (e.g., the customer) with a focal agent/object (e.g., a brand, organization, community) in focal relationship (e.g., service), and is characterised with varying valence (positive versus negative) and intensity (high versus low) [9, 22]. It manifests itself in a context- and/or stakeholder-specific expression of relevant cognitive, emotional and/or behavioral dimensions [22]. An important perspective in defining the CE concept is its embedding in the value co-creation paradigm [22], which allows to move away from purely marketing interpretations of the notion. According to Grönroos [20, p. 1520], co-creation is defined as *joint activities by parties involved in direct interactions, aiming at contributing to the value that emerges for one or both parties*. Following Sulkowski et al.'s [28] adaptation of stakeholder theory, the relationship between the enterprise and the stakeholder network can be seen as a process of creating shared value for the benefit of the wider system. Such a perspective forces to move beyond reacting to stakeholder pressures towards a conscious co-engagement of the enterprise with its stakeholders in creating shared benefits for the enterprise, society and the environment [28]. The enterprise needs to see its role in this network as a proactive one, which includes stakeholder shaking out of a state of complacency in order to get them to participate and collaborate in changing their own behavior to change broader social or market conditions, or even shaking the network of relationships for broader adoption of sustainable practices [28].

Consumers should be considered the most important stakeholders of the company, as they have a direct impact on its survival and development. At the same time, one of key drivers of unsustainable development is consumption behavior, and consumers and their consumption patterns play an important role in efforts to make businesses and industries more sustainable [14]. However, the claim of full consumer responsibility in this regard must be rejected. Kopnina and Blewitt [21] emphasise that people cannot be expected to act against their nature and that actions towards sustainability will occur on their own, only through individual decisions. The role of governments, business and consumers is crucial in terms of changing the dominant paradigm of modern society, which is consumerism. A prerequisite for this change is to shape customer relationships in such a way that they foster so-called sustainable consumption, which refers to *consumer behaviour that improves his/her quality of life while minimizing or eliminating social and environmental damage throughout a product's life cycle* [11, p. 370]. Sustainable consumption refers to individuals' acquisition, usage and disposal of goods and services, which consider the impact of ecological and socioeconomic conditions for current and future generations [17].

The relationship between the company and consumers (as stakeholders) in the context of corporate sustainability has to be considered from different perspectives. First of all, through incorporating and meeting customers' needs and expectations in a manner consistent with their long-term interests, the transaction between the enterprise and the consumer have also social and environmental, short- and long-term consequences, finally, consumers can be active participants in sustainable development activities together with the enterprise [11, 28, 33]. In the literature, customer engagement behavior towards sustainable practices is also understood as customers' behavioral manifestations that moves beyond the transaction [9].

Engaging customers for sustainability addresses:

- offering sustainable products [11, 14, 33], covering: products of an adequate quality to ensure that consumers' needs are properly met, safe for their health and life in the short and long-term while minimizing or eliminating social and environmental damage throughout a product's life cycle; products adequately described so as to encourage informed consumer choices; the use of sound arrangements for dealing with complaints, claims and grievances; ensuring service, access to spare parts and repairs throughout the life cycle of the product; non-discrimination against consumers and including previously excluded groups; effective protection of consumers' personal data and privacy;
- actively seeking customer feedback and involving customers in co-creating products, allowing them to participate in the design and development process [14, 21];
- educating customers about sustainable practices, raising awareness and promoting a shift in attitudes towards more sustainable choices [14, 21];
- engaging customers to join a community of sustainable choice advocates [14]. Kunz et al. [22] argue that customers are motivated to communicate information based on disparate goals such as through sense of obligation, a desire to help others/altruism, and/or a feeling of pleasure from telling others about products or gaining social capital;
- engaging customers in collaborative initiatives [28].

However, the extent and manner in which customers are engaged in sustainability efforts may not be the same for all customer groups. Above all, the choice depends on their motivation and willingness to get involved in selected sustainability issues [11, 22]. Consumers are more likely to identify themselves with

companies operating in line with their values [9]. For sustainability oriented consumers, both purchasing and other forms of social and environmental engagement are expressions of their moral choices [9, 11]. However, customers' motivations for engagement need to be looked at more broadly, and may stem from a desire to justify their decisions, achieve social status, to increase self-esteem, self-enhancement, and visibility [22]. Understanding differences between customers' needs and motivations support development of different approaches across customers groups to improve their responses. Strongly supported in the literature is the view that consumer behavior is only influenced by business CSR practices if the consumer is truly aware of these practices. Communicating business initiatives to relevant stakeholders in an appropriate manner therefore emerges as crucial and, as González-Rodríguez and Díaz-Fernández's (2020) research in the tourism industry demonstrates, adopting an adequate approach to link consumer awareness to consumer attitudes and behaviors is required [18]. What is more, not every customer welcomes engagement efforts or prefers to engage in a certain way, as relational orientations vary from customer to customer. According to Kunz et al. [22], attachment styles (systematic patterns of relational expectations, emotions and behaviors that stem from a specific personal history) can help explain customers' motivations to engage with companies. Finally, business co-engagement with its customers on sustainability depends on the willingness of the company itself to engage in sustainable value creation. For many companies, sustainability practices are still only part of their business practices (often an add-on to their core business), and experimenting with different ways of co-engaging in sustainability with consciously selected consumer groups allows the company to gradually transform towards a more sustainable business.

2.2. Personalization in e-commerce

There is an escalation of interest in sustainability issues in e-commerce [7, 25, 34]. Zhang [34, p. 1728] argue that e-commerce represents *a radical transformation throughout the production and consumption journey, as e-commerce embeds more information flow, and rewrites the traditional way of how production can be processed and consumed*. Although, there is a lack of comprehensive theory that pivots sustainability transition into the context of e-commerce [34], bibliometric analyses of 104 articles by Rita and Ramos [25] and 58 articles by Zhang [34] show that sustainability in e-commerce relate to several issues like: new types of consumption (e.g., collaborative consumption), resource consumption and resource allocation in relation to transport, last mile distribution, dual-channel and carbon emissions, energy consumption, smart packaging and others. Still, the empirical results show that there is not enough awareness of the potential of this channel to promote sustainable development [7].

As in the consumption end, the potential of e-commerce in sustainability context lies in technological advancement which reshapes how companies interact with their consumers, companies are better able to meet consumers' demands and to encourage consumers to co-create value [34]. Since the primary point of contact between the company and the customer is the user interface, attention should be focused there [32]. Addressing sustainability issues can be a direction for personalization and improving the user experience (UX). Personalizing the user interface of information systems (including e-commerce) means tailoring the appearance and content to the requirements, needs, expectations, and behaviors of users [24].

Sustainability-oriented actions seem justified, as more than half of online shoppers prefer brands that care about sustainability and the environment. Socially innovative offerings are desired by both private and public sector customers, but are not reflected in the actions of companies, providing an opportunity for those who recognise this to gain a real competitive advantage. Despite the economic challenges ahead, some business owners remain focused on sustainability projects, which was cited as the most important opportunity for 2023 by 16% [4]. On the other hand, a lack of basic knowledge or motivation can prevent e-commerce customers from making sustainable choices, which is clearly reflected in their consumer behavior [27]. Therefore, the key to understanding customer attitudes and determining strategies for personalizing messages (including those related to sustainability engagement) is to gather and analyze information about e-commerce user behavior [10]. Today, technical issues are not a limitation in this regard and allow the use of advanced methods of collecting (as so-called clickstream) and processing (e.g., using deep learning) this type of data. In practice, legal issues are a bigger problem – collecting data on customer behavior can raise privacy concerns, but proper communication and transparency provide the basis for minimizing user concerns, which in turn leads to maintaining or even increasing the propensity to purchase online ([2]). As a result, when analyzing customer behavior, it is important not to overlook information that users explicitly, knowingly, and voluntarily provide, such as through reviews and recommendations. It can also be helpful to use data integration to take advantage of information stored in enterprise resource planning (ERP) systems [30]. Another concern at the intersection of technology and law is the use of artificial intelligence (AI). Attention should be given to the potential risks of AI applications and how they affect customers' perceptions of UX. Primary problems may include a lack of human interaction, a loss of privacy and control, significant time consumption, possible feelings of annoyance, etc. [5].

Efforts to personalize communications with e-commerce customers date back almost to the beginning of this channel's dynamic development [1]. In general, 3 dimensions of personalization can be identified – what to personalize (content, interface, functionality, channel), to whom to personalize (users or groups of users), and who does the personalization (implicit or explicit personalization) [15]. However, at a time when data-driven approaches are rapidly evolving, it is also worth keeping in mind a fourth dimension related to the vast possibilities of using analytical techniques and tools that leverage machine learning and artificial intelligence [35]. The complexity of personalization issues in e-commerce requires formalization, such as the development of a framework that allows activities to be systematized. Literature reviews on the development of personalization in e-commerce [1] and the importance of emotions in this process provide additional help in formulating new concepts, including those that take sustainability into account. At the same time, it should be remembered that the personalization analysis of online systems should be conducted in terms of the actual actions taken (actual personalization), but also in terms of the recipient's perception of these actions (perceived personalization). The results obtained may not always coincide, and more weight should be given to perceived personalization [23]. On the other hand, when implementing the concept of personalization based on Artificial Intelligence (AI), it is important to emphasize the importance of analyzing the entire customer journey when implementing personalized marketing activities [16]. It is important not to focus only on the most popular solutions, such as product recommendations, but to try to take full advantage of all opportunities to tailor communications to customers [31]. Nevertheless, by mastering data (including user behavior data), brands can unlock per-

sonalized experiences – critical to standing out in a crowded e-commerce landscape – and forge deeper customer relationships [4].

In conclusion, personalization in e-commerce is important and the need for it is recognized by customers, businesses and researchers. By writing into it the desire to engage in sustainable development, it is possible to try to determine the scope of the target e-commerce solution that takes into account the sustainability strategy of different online channels, including aspects of value-centered thinking, consideration of the relationship between the content provided and energy consumption [6], and tools that reduce the problems of urban logistics (e.g., so-called last mile delivery), since sustainable e-commerce logistics, both in order fulfillment and returns processing, are also often emphasized [29]. The overall solution is a complex composition, but at its core is undoubtedly the personalization of the user interface. It allows to tailor selected UI variants to specific customer behaviors (e.g., pro-environment) and serve them to deepen their engagement in sustainability. The lack of such analyses in the literature can be seen as a research gap that deserves a closer look. This problem is addressed in the paper, which has a practical contribution (empirical verification of the effectiveness of multivariate UI personalization) and a consequent theoretical contribution (development of a sustainability-oriented framework for multivariate UI in e-commerce).

3. Method

The user interface is the primary way to reach customers in e-commerce. In order to engage the customer or show the company's commitment, various UI modifications can be made. These can be comprehensive, affecting the entire site, or partial, based on specific micro-changes (Table 1).

Table 1. Approaches to multi-variant UI

Approach	Advantages	Limitations
static (comprehensive redesign)	• consistent communication policy • opportunities for full engagement • no need to use complex information systems	• one UI variant for everyone, including the non-engaged • compromises required • lack of adaptation to customer behavior
Dynamic (tailored micro-changes)	• ability to use multiple UI variants • customized modifications served to specific customer groups • better tailoring of modifications to customer behavior	• required complex UI recommendation and serving mechanism • customization options limited to pre-defined UI modifications • potential *cold start* problem

The first approach can be accomplished by redesigning the pages of an online store to either include desired content, reduce the carbon footprint, or be more accessible to people with special needs. While redesigning pages can address many aspects of sustainability, it does not address the underlying problem – the diversity of customers, their lifestyle attitudes and expectations. For example, a desire to reduce a website's carbon footprint (measured by the amount of data uploaded after visiting the website) means

fewer (or lower quality) images, which some customers may find unappealing. Similarly, a strong emphasis on sustainability in communications with all customers may discourage those who are not engaged or even negative about such an attitude.

The solution to this problem can be found in the second possible approach – providing customers with different UI variants that differ in a number of micro-modifications. Based on the customer's actions (expressed either explicitly, by choosing a version, or implicitly, by the activities performed in the online store), it is possible to serve such a version of the UI that best suits the customer's requirements, needs, or decisions. In this way, you don't have to compromise on the UI design and deliberately leave out some potential customers, but you can tailor the layout to different groups and address all key needs, including sustainability. The basic idea of serving multi-variant UIs is to allow the layout of an online store to be tailored to the behavior of specific customer groups. Achieving this goal requires the interaction of several components that translate the specifics of e-commerce usage into dedicated UI variants (Figure 1). The architectural basis of the solution can be the SOA (Service Oriented Architecture) paradigm [19], which allows the design of a tool that is flexible, scalable, and easy to maintain and develop.

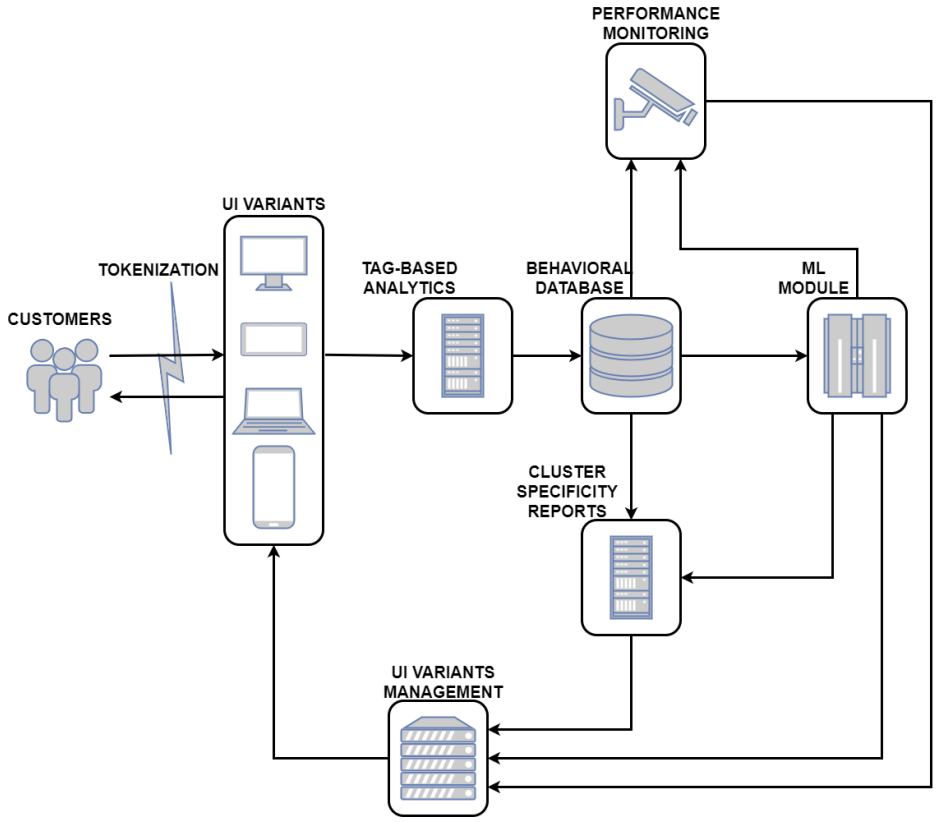

Figure 1. General framework of multi-variant UI solution (based on [31])

The foundation of any personalization effort is to know the characteristics of the recipients of targeted messages. In this context, the first, but at the same time crucial, task is to collect information about the behavior of online store customers. The most accurate customer journey can be reflected in the form of clickstream, i.e. a detailed record of all actions taken by users on the online store's websites. The data collected should include all user activity (e.g., filter selection, search, page transitions, image viewing), context (e.g., current website, UI variant served), and time spent on each web store page. In carrying out this task, privacy issues must not be overlooked. On the one hand, this means informing customers

that their use of the system is being tracked, and on the other hand, making every effort to ensure that the data collected remains anonymous. Tokenization can be used to achieve this goal, and each customer can be identified by this identifier, rather than using solutions based on email address or specification of the electronic devices used. It should be noted that the use of unique identifiers (such as the universally unique identifier (UUID)) is not without its drawbacks, the most important of which is the inability to link user sessions across devices and the likelihood of linking sessions of different users across the same device. Nevertheless, such a solution can be considered a satisfactory compromise between ensuring customer anonymity and the usefulness of identifying e-commerce user sessions.

The next important component of the described system are the user interface variants. They are served to selected groups of customers and iteratively tailored to their behavior and decision-making. The rate at which UI variants are tuned can vary from cluster to cluster, depending on the feedback collected. A separate dedicated variant can be served to new customers – those whose behavior has not been previously identified and analyzed. In a typical online store, this is usually a very large group of users (reaching up to several tens of percent of the total population), so it is worth taking care of their experience by offering communication introducing them to shopping, presenting how to use the system or familiarizing them with the brand and products. This element of the framework is the point of contact between the customer and the business and the most visible manifestation of personalization from the user's perspective. Therefore, care should be taken to ensure that it best meets the expectations of online store visitors, as the perception of the entire approach and its measurable effectiveness depend on it.

Another component allows initial analysis of the collected data on user behavior based on tags – pieces of code or metadata added to various elements of a web page to track user interactions, measure performance, and gather insights into user behavior. The selection of tags allows to define the actions that will be taken into account when grouping and analyzing the specific behavior of each customer segment. The right choice of tags also makes it possible to target the data collected, for example to highlight sustainability issues.

The central component of the solution is a database of collected information on customer behavior. It includes information obtained from tracking customers in the online store, as well as additional data related to product descriptions, categories that are part of the learning data set, and optional order fulfillment statuses that are an important element of performance evaluation. This part of the solution provides the information necessary for the proper functioning of customer clustering, analysis of the characteristics of each cluster, and verification of the impact of implemented modifications for customer decisions.

The ML module includes functions related to preprocessing and clustering. Data preprocessing involves cleaning the data, making it consistent, and linking it to additional sources (e.g., product feeds) to produce a dataset that can be processed using a clustering algorithm (or algorithms). In turn, when choosing the parametrization method and initialization parameters, it is necessary to take into account a number of factors that determine the possibility of practical use of the obtained results: computational complexity, quality of clustering results and fit with the business context.

The first aspect is related to the size of the learning datasets. Given the nature of the clickstream, a very large amount of data should be expected, which can be augmented by associating it with additional information in the preprocessing stage. This means that computationally complex algorithms (e.g., agglomerative clustering) will not be efficient in clustering customers to serve them dedicated UI variants.

The second aspect relates to clustering quality in a broad sense, ensuring that data points within clusters are more similar to each other than to those assigned to other clusters. Various measures such as the silhouette score, Davies–Bouldin index, Dunn index, Calinski–Harabasz score, etc. can be used to evaluate algorithms in this regard. When selecting a set of metrics, it is important to keep in mind that the resulting recommendations may vary depending on the indicator, so the decision should be based on an aggregation of several of them, rather than on a single measure.

The third aspect is how to use the clustering results. When serving multivariant UIs, it makes sense to have groups of similarly sized clients. The reason for this is the rationality of designing dedicated UI modifications – due to the cost of such actions, they should be used as often as possible, and this can only be ensured with sufficiently numerous clusters. In addition, the expected number of resulting clusters is not insignificant. For the majority of available algorithms, it is set as a parameter that initiates clustering, but there are also methods (e.g., DBSCAN) where the generated clusters cannot be predicted, which can be considered a significant drawback in the described business context.

The next component allows us to generate reports describing the differences between the behavior and decisions of customers assigned to clusters. In order to design specific modifications, it is necessary to know the characteristics of each user cluster. On the one hand, it is derived from the values of the parameters describing the cluster, such as the mean and variance of selected attributes (number of user actions, search engine usage, purchase value, etc.) or the dominant values in the case of discrete attributes (selected size, color, etc.). On the other hand, comparing clusters of the frequency of specific actions and their sequences can reveal key differences in customer behavior that should be addressed in a dedicated UI variant.

The UI modifications introduced in the next component can be inspired by various factors. First, these may be ideas from UX specialists that, for various reasons, were not included in the design of the standard layout because of the need for compromise. Second, modifications may result from a desire to address the needs and requirements of certain important, though not necessarily the most important, customer groups. An example might be efforts to appeal to sustainability-oriented users. Third, the characteristics of customers in clusters and the characteristics that differentiate clusters may provide clues for the design of UI modifications. The developed set of potential UI modifications provides a basis for tailoring UI variants dedicated to different customer segments. The selection of specific sets of customizations can be done in two ways – based on the knowledge and experience of UX experts, or based on the self-adaptation mechanism, which can be treated as automatic, iterative A/B tests, the result of which is the acceptance or rejection of subsequent micro changes. The result of this component is the implementation of dedicated UI variants that are served to clients, completing the process of developing a multi-variant user interface.

The last component of the solution allows tuning the UI based on feedback from customers who were served dedicated variants. Various types of metrics, both macro- (e.g., conversion rate (CR), average order value (AOV)) and micro-conversion (e.g., click-through rate (CTR), partial conversion rate (PCR)), can be used to assess the impact of the changes implemented. The first three are the most popular metrics for assessing the quality of personalization in e-commerce ([26]), and the last one was introduced to enable analysis of the impact of implemented modifications on the sequence of actions taken by customers. PCR is calculated using the following formula [31]:

$$\text{PCR}_c = \frac{1}{n}\sum_{i=1}^{n}\sum_{j} = 1^s CVV_{ij} \tag{1}$$

n is the number of sessions related to customers from the cluster c, s is the number of activities within the session n, PCR_c is the calculated PCR metric value for the cluster c, CVV_{ij} is the score of an activity j during a session i.

This metric provides a high degree of flexibility in the choice of activities studied and the ability to prioritize them (by setting different CVV values for actions), making it useful for studying the impact of changes on different elements of the UI without having to wait for the purchase process to be completed.

The described framework for a solution that allows the preparation and implementation of a multi-variant user interface in e-commerce can be further developed with additional components, such as the personalization of content served in different UI variants. One of the potential applications could also be tailoring customer communication to sustainability principles. However, any extension or adaptation of the proposed solution should be preceded by verification of the practical effectiveness of the basic version of the system, so that the economic rationality of such an approach can be justified.

4. Empirical research

The primary objective of the experimental research conducted was to answer research question $RQ2$. The experiment consisted of two phases – in the first phase, customers of an online store operating in the sportswear market were clustered, and in the second phase, selected groups of users were served modified UI variants. Verification of the PCR values for the two customer segments under study was the basis for drawing conclusions and further discussing the possibility of using multivariant UIs to increase sustainability engagement.

4.1. Clustering

In this part of the study, 810 250 customer sessions collected over 7 months were used as a learning set. The data was in the form of a so-called clickstream and included a detailed record of user activities (e.g., pages visited, decisions made, search terms used, etc.) and the context of these activities (e.g., time spent on the website, customer location, devices used, etc.).

Table 2. The cluster sizes for different values of the parameter k

Size	$k=3$	$k=4$	$k=5$	$k=6$
Smallest cluster (users)	35,842	35,836	26,259	20,225
Smallest cluster (percrntage)	19.0526	19.0494	13.9586	10.7511
Largest cluster (average)	93,947	58,332	35,6292	38,408
Largest cluster (percentage)	49.9397	31.0077	29.9233	20.4166

K-means was chosen as the clustering method, which has been found to be optimal in previous studies for both clustering quality and computational complexity [31]. To determine the number of clusters (k), clustering was performed for $k \in \{3, 4, 5, 6\}$ and verified for which value of k the smallest cluster

contains at least 15% of the customer population. The results are shown in Table 2, and based on them, $k = 4$ was used in the study.

The effect of clustering was to generate groups (segments) of customers whose basic characteristics are shown in Table 3.

Table 3. Features of the generated clusters

	Cluster 0	Cluster 1	Cluster 2	Cluster 3
Size (users)	35,836	56,292	58,332	37,661
Size (percentage)	19.0494	29.9233	31.0077	20.0196
Actions (average)	38.6881	17.7980	108.2462	13.1308
Events (average)	10.7610	3.2276	36.6153	3.7574
Revenue (average)	2.9536	0.0802	12.6334	0.3127

Based on this data, it can be seen that cluster 2 contains the most active customers who make large purchases. This is a group that should be particularly valued in order to maintain their loyalty. In cluster 0, there are moderately active customers who should be encouraged to buy more, but at the same time it is worth taking their habits into account and not making revolutionary UI changes. Cluster 3 includes customers who are not very active, but who buy something from time to time. This group can be encouraged to spend more time in the e-store in the hope that this will translate into more orders. cluster 1 contains low activity customers who buy virtually nothing. They can be attracted by offering a dedicated UI and trying to engage them in various ways to stay in the store and perhaps make a purchase. Another way to verify the clustering results was to analyze the visualization of the clusters. Figure 2 shows the visualization of the clusters using the Uniform manifold approximation and projection (UMAP) technique.

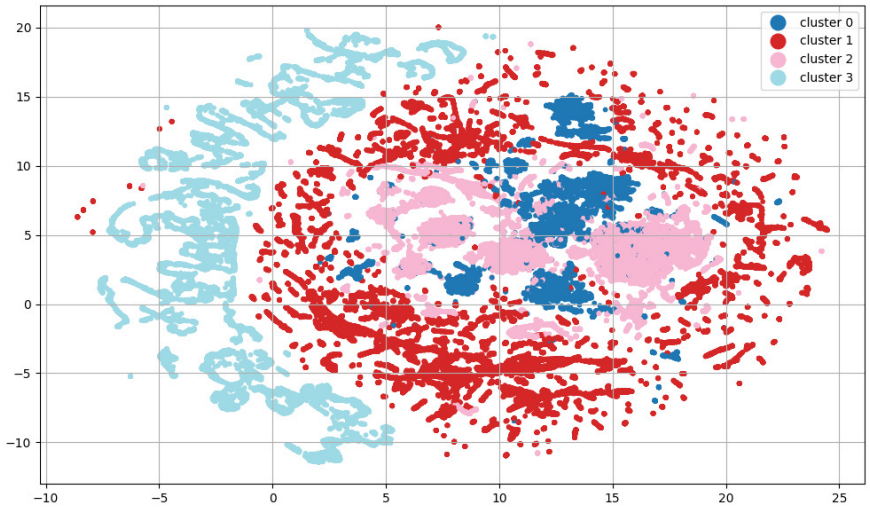

Figure 2. Visualisation of the clusters using UMAP

An alternative approach to cluster visualization, t-SNE, was used for Figure 3. It should be added that UMAP and t-SNE are only techniques for visualizing multidimensional data in a low-dimensional space, so they cannot be analyzed quantitatively (the effect of which is therefore the lack of description of quantities on the axes).

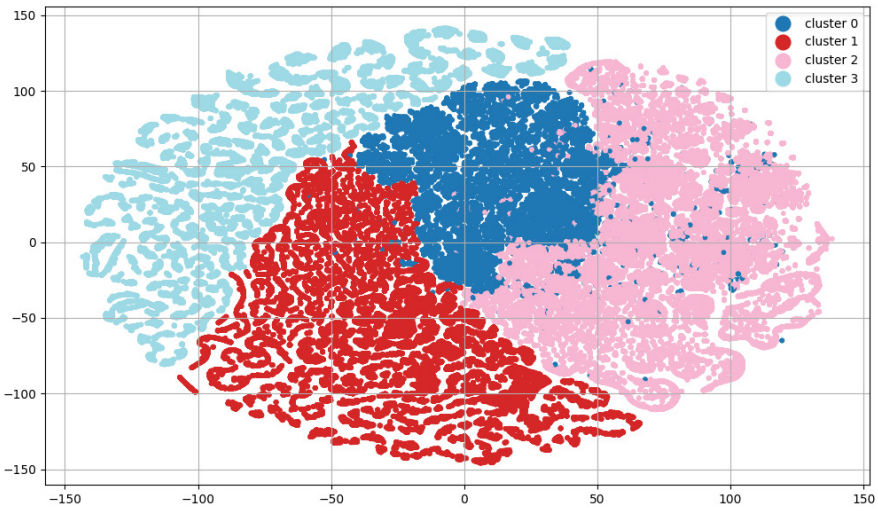

Figure 3. Visualization of the clusters using t-SNE

4.2. Verification of the effectiveness of tailored UI variants

The aim of the research was to verify the impact of the implemented changes on the customer behavior in the online shop. For the generated user clusters, an analysis of the specific actions taken by them (actions and action sequences) was carried out, and based on this, modifications to the corresponding UI variants were proposed. The number of change proposals varied and was as follows:

- for cluster 0 – 4 modifications,
- for cluster 1 – 8 modifications,
- for cluster 2 – 7 modifications,
- for cluster 3 – 12 modifications.

Sample modifications included: the "add to wishlist" button, the way the free shipping amount is displayed, the category filters, the search engine (cluster 0), as well as detailed product description, page header, right column of product description, model information, photo gallery (cluster 1).

The next step was to implement the changes and served them to customers for 45 days. It was assumed that half of the customers in each cluster would be served a dedicated UI variant and the other half would be served a standard variant. This is the approach used in classic A/B testing to evaluate different versions of the user interface.

A total of 332,312 user sessions were collected during the research period. The number of sessions per UI variant studied is shown in Table 4 (row Observations). The different number of sessions between the dedicated and standard variants within the clusters is due to the random distribution of customers and the frequency of their use of the online store during the study period. For each session, the PCR value was counted, taking into account the following activities and point values:

- moving from the home page to the listing or to the product card – 10 points,
- adding the product to the cart – 20 points,
- change of product card – 5 points.

The method of calculating PCR values was the same for all clusters and all UI variants. The means and variances calculated for each UI variant within the clusters are shown in Table 4.

Table 4. Results of UI variant effectiveness studies

Interface	Cluster 0		Cluster 1		Cluster 2		Cluster 3	
	Dedicated	Standard	Dedicated	Standard	Dedicated	Standard	Dedicated	Standard
Observations	1010	1006	2562	2470	3690	3616	5771	6171
Mean (μ)	40.85	34.46	30.15	32.26	48.03	44.41	49.77	52.75
Variance	6713.86	5509.94	2615.89	3929.27	7886.31	6818.14	7478.41	9487.58
H_0	$\mu_d - \mu_s = 0$		$\mu_d - \mu_s = 0$		$\mu_d - \mu_s = 0$		$\mu_d - \mu_s = 0$	
H_1	$\mu_d - \mu_s > 0$		$\mu_d - \mu_s > 0$		$\mu_d - \mu_s > 0$		$\mu_d - \mu_s > 0$	
H_2	$\mu_d - \mu_s < 0$		$\mu_d - \mu_s < 0$		$\mu_d - \mu_s < 0$		$\mu_d - \mu_s < 0$	
$tStat$	1.8253		-1.3051		1.8039		-1.7727	
$P(T \leq t)$ one tail	0.0340		0.0959		0.0356		0.0382	
Conclusion	H_0 rejected H_1 accepted		no basis for rejecting H_0		H_0 rejected H_1 accepted		H_0 rejected H_2 accepted	

The study then tested the hypotheses to determine if two population (customers who were served a dedicated UI variant and customers who were served a standard UI variant) means were equal. For this purpose, we used the two-sample t-test. The primary hypothesis was equality of mean PCR values ($H_0 : \mu_d - \mu_s = 0$), where μ_d was the mean for the dedicated UI variant and μ_s was the mean for the standard UI variant. Alternative hypotheses assumed that the means were different:

- $H_1 : \mu_d - \mu_s > 0$ – dedicated UI variant is better than standard variant,
- $H_2 : \mu_d - \mu_s < 0$ – dedicated UI variant is worse than standard variant.

The calculated t-values and the resulting conclusions about the hypotheses are shown in Table 4. The equality of means hypothesis was tested independently for each customer cluster. The H_0 hypothesis was rejected for three clusters. For one cluster, there was no reason to reject the H_0 hypothesis. Twice, H_0 was rejected in favor of H_1, meaning that the effect of the implemented UI changes on the PCR values was positive. Once H_0 was rejected in favor of H_2, and for this cluster the implemented modifications were not successful, as they resulted in worse PCR index values.

5. Discussion

5.1. Results and limitations of the experimental research

The primary objective of the experimental study was to answer research question RQ2 (*Do dedicated e-commerce user interfaces affect customer behavior?*). The results show that for 3 clusters, the implemented UI changes influenced customer behavior as measured by the PCR indicator. This means that by tailoring the user interface to specific groups of customers with similar characteristics, you can influence their behavior when using the online store.

However, it is worth noting some additional findings from the survey and the limitations associated with them. The first issue concerns the selection of modifications for UI variants. In the study, expert knowledge and information about characteristic activities and activity sequences within clusters were used to determine the changes. The results showed that such an approach does not necessarily lead to improved PCR values. This means that in practice one should expect an iterative (trial and error) investigation of the optimal version of the UI variant. In such an approach, it would be necessary to avoid

implementing multiple changes simultaneously (as was the case in the described study) in order to clearly identify changes that positively affect the target function (e.g., the average PCR value) and those that negatively affect it. The disadvantage of single modification verification is the time required to complete each iteration. To obtain statistically significant results, a sufficient number of observations must be collected, which can be time-consuming for clusters that contain low-activity customers. Differences in the number of sessions in each cluster were also observed during the empirical study.

Another point worth discussing is the design of the PCR indicator. It provides the flexibility to study specific customer activities in the online store, which enables different types of analysis. During the experimental study, the PCR was defined in terms of the shopping path and scored transitions to the next steps of the shopping process (including adding products to the shopping cart). However, it is possible to select and score other activities, such as those related to sustainability. For example, if the PCR indicator is to be used to analyze the impact of UI changes related to the pro-environmental approach, it can be applied to score the use of specific search terms, entries in product cards marked as environmentally friendly, development of product ingredient descriptions, visits to pages (e.g., blog) containing information on sustainability, and so on.

Another noteworthy observation is the number of user sessions served by the dedicated UI variant. It turns out that it varies significantly within clusters (as mentioned above), but is also generally small relative to all sessions. The total number of sessions assigned to clustered clients was 26,296, representing less than 8% of all sessions during the study period (which was only 45 days). This effect is due to the peculiarities of e-commerce, where the rate of returning customers is relatively low, usually estimated at 20–30% of customers returning within 12 months. This means that when designing tailored UI variants, new customers of an online store should not be overlooked. Moreover, it is worth treating them as an additional *super-cluster* and preparing a dedicated UI variant for them as well. This allows to address their needs and familiarize them with the online store, improving their user experience.

A final point for comment is the impact of the changes on macro conversion rates. The PCR used in the study refers to micro-conversion and allows the analysis of individual activities and their sequences. Meanwhile, from the point of view of business profitability, attention should also be paid to the financial effects that result directly from the orders placed by customers. Therefore, it is worthwhile to combine the analysis of the impact of the implemented UI modifications on micro-conversion and macro-conversion, prioritizing the indicators used. In the case of changes aimed at increasing economic efficiency, macro-conversion indicators (CR, AOV) may be more important, but in the case of a desire to increase environmental awareness or engagement in sustainability, more emphasis can be placed on properly defined micro-conversion indicators, such as the PCR described above.

5.2. Conceptual framework to support sustainability

The advantages of a platform that allows you to serve a multi-variant UI can be used to tailor the layout of your online store to the preferences of customers engaged in sustainability. To do this, however, it is necessary to make modifications, customize mechanisms for analyzing behavior, designing modifications, and verifying the results of the actions taken. The changes do not affect the overall design of the framework, but touch almost all of its elements. Components that require customization are highlighted in Figure 4.

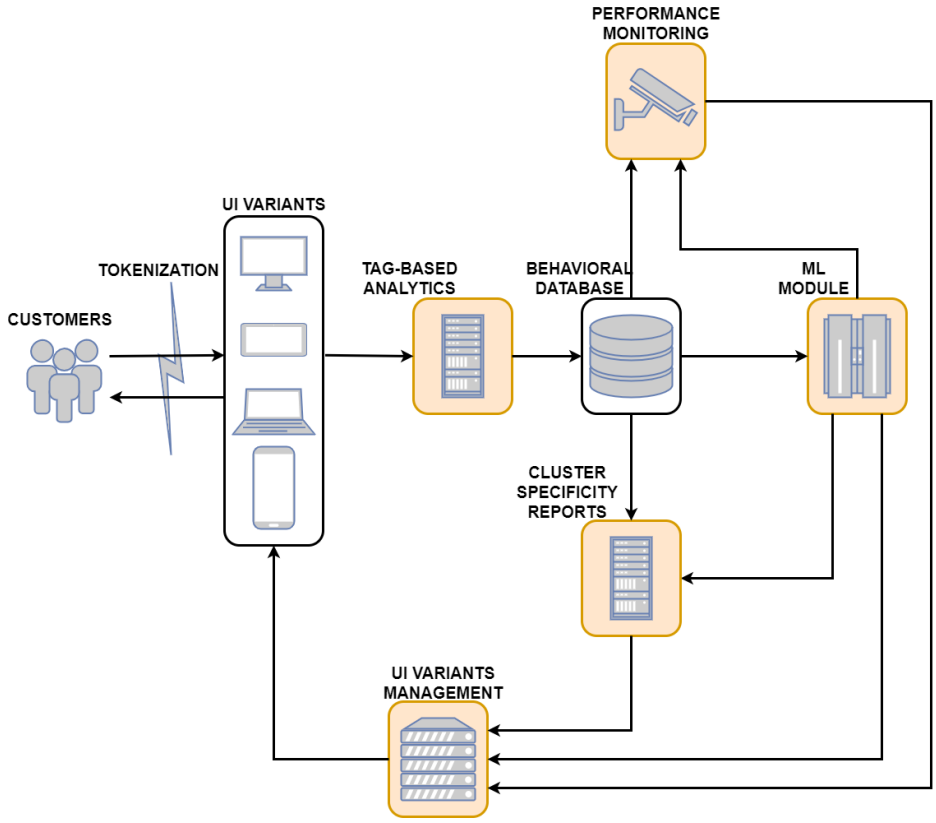

Figure 4. Updated framework of multi-variant UI solution

A summary of the modifications to the basic multivariate UI framework in the context of its adaptation to support sustainability engagement is presented in Figure 5.

Activity	Data collection	Customer segmentation	Searching for differentiators	Designing of UI variants	Serving dedicated variants	Monitoring and optimization
Tool	Tag-based mechanism	Clustering	Cluster characteristics and behavioral reports	Micro-change designer	Customized e-commerce platform	Performance indicators
Result	Customer behavior data	Customers in clusters	Characteristics of customers in clusters	Tailored micro-changes	Cluster-specific UI	General performance evaluation
Sustainability-oriented add-ons	Tag collection update	Modification of clustering priorities	Sustainability-focused characteristics	Sustainability-centric micro-changes Static UI variants	Cluster-specific UI Improved UI	Sustainability-focused assessment

Figure 5. Scope of framework modifications to support sustainability

Relating directly to theory of customer engagement for sustainability, some recommendations for using multi-variant UI may be formulated. For selected group(s) of customers:

- offering more sustainable products and services through suggestions based on collaborative filtering;
- providing additional (sustainability) information about product environmental and social impacts throughout the life cycle through additional tabs, links to specific information, more visible selected descriptions. It may concern product information, like materials (for traceability of materials and

substances), energy efficiency, durability, possibility of reuse and extension of product lifetime, reparability and safe disposal; information on technologies used in terms of resources consumed and pollution generated during production, logistics, use, repair, disposal processes (but also on the results of improvement actions to prevent emissions and waste of resources); information about suppliers and their practices etc.;

- providing more sustainable ways of offering and delivering products, including alternative versions of product (for example with different product material composition), alternate delivery methods (in terms of reducing the carbon footprint), offering reverse logistics options; possibility to switch to an interface that reduces the carbon footprint of a website etc.;
- launching customers feedback channels on the shortcomings of the products and services and suggestions for their improvement in terms of social and environmental benefits and harms (involving customers in the co-creating of products);
- providing opportunities to co-engage in broader campaigns in a social or environmental cause in which the organization participates (for improvement of public health or safety, the state of the environment or the situation of communities) and to join the company's sustainability initiatives, including supporting customers involvement in the development of sustainability-oriented innovations and even new standards for the operation of industries or even new regulations;
- providing additional, highly visible information on sustainability issues to increase social or environmental awareness and interest (to educate customers about sustainable practices, raise awareness and promote a shift in attitudes towards more sustainable choices);
- offering functionality to share their [customers] sustainable choices or involvement in sustainability initiatives.

Further development of the solution described to support the sustainability of e-commerce will aim to add other activities to those mentioned above. Their continuous development and improvement will depend on customer behavior according to the human-in-the-loop concept.

6. Conclusion

The paper aimed the adaption of the general framework that enables the delivery of multi-variant e-commerce UI to shape customer engagement for sustainability. Its accomplishment involved addressing three research questions (RQ1-RQ3), and was preceded by a literature review (Section 2). We have shown that business contribution to sustainable development is realized, among others, through relationships with various stakeholders, including customers. The customer engagement for sustainability was discussed and structured based on the concept of customer engagement and the concept of business sustainability (embedded in stakeholder theory) (RQ1). Multi-variant e-commerce UI, described in Section 3, was recognized as a tool with potential to support a company's efforts in shaping customer engagement for sustainability. A general framework for multi-variant user interfaces in e-commerce was selected and presented, and the potential impact of dedicated user interfaces in e-commerce on customer behavior was empirically substantiated (RQ2).

The general framework of ML-based multivariant user interfaces in e-commerce was used in an empirical study that showed the potential business benefits of its application in practice (Section 4). This

solution has been adapted (Section 5.2) so that it can be used to shape customer engagement for sustainability (RQ3). The results also formed the basis for a discussion (Section 5.1) that highlighted the advantages and disadvantages of the proposed concept, its limitations, and possible directions for further research. Admittedly, the identified areas still need to be empirically verified, both in terms of their relevance to engaging customers in more sustainable consumption and in terms of business profitability, but the proposed framework for multi-variant UI in e-commerce, and its initial verification can form the basis for planning dedicated experiments and thus a solid foundation for further research in this area.

Finally, it should be emphasized that the concept of using dedicated UI variants to promote sustainability introduced in this paper is only one of the potential application paths for such a solution. Although the design of human-computer interfaces (HCI) in e-commerce has primarily an engineering dimension and is of interest to those responsible for UI/UX, the perspective presented represents an opportunity to synergize different approaches to more fully engage the e-commerce customer.

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