Gamifying responsibly: Sustainable HCI for the future

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Abstract

With the ever-rising consideration for holistic sustainability in contemporary technology, there is a dearth of knowledge of how pursuits among design can and have been responsibly re-configured towards these ends. Therefore, in this paper, we explore the potential of responsibly implementing gamification as an innovation in sustainable consumption apps (SCAs) to deepen the understanding and knowledge about the development process of sustainable human-computer interaction (SHCI). We utilize gamification design practice as our contextual case as it both imbues sustainability in the design ethos and as the modus operandi of the technology itself while simultaneously being susceptible to several moral hazards. This qualitative study employs the prism of responsible research and innovation (RRI) dimensions as the kaleidoscopic lens for analyzing the data gathered through key-informant, semi-structured interviews among 21 SCA creators. Moreover, the study links the SCA creators' perceptions of risks for the users with a series of app users' needs to highlight areas of concern to gamify SCAs responsibly. The overview of all findings is presented as recommendations for HCI practitioners and interested stakeholders to use RRI dimensions as a guideline to make informed decisions for the responsible development of SCA. These recommendations include considering sustainability values and ethics as a prerequisite for decision-making from the conceptualization phase onwards, implementing multi-stakeholder, participatory design processes, cross-cultural cooperation to enable socially desirable outcomes, and developing and implementing responsive accountability practices to nurture a sense of shared responsibility.

Keywords

Sustainable human-computer interaction, responsible research and innovation, gamification, sustainable consumption, mobile apps

1. Introduction

We are contemporarily living in a global culture where sustainability is emphasized as the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" ([1] n.p.), applied to all spheres of human activities, calling for collaborations between social and natural sciences to understand their interactions [2]. Part of these processes rely on technological solutions to make everyday choices, from increasing an efficient use of natural resources to facilitating the advancement of interconnected, digital societies in ways that reduce inequality and wellbeing gaps, both for people and the environment.

The people behind these technologies have a twofold challenge: develop solutions that enable users to act sustainably; and, behave themselves more responsibly when creating these solutions. Hence, Sustainable Human-Computer Interaction (SHCI) has been gaining relevance for over a decade as a research discipline through two categories: sustainability *in* design and sustainability *through* design [[3], [4], [5], [6]]. The former concerns itself with efficiency and digital services, like enabling circularity through the products' physical attributes. The latter relates to applying HCI to support decision-making processes to lead more sustainable lifestyles. Due to the rapidly evolving nature of HCI, it is necessary to find frameworks that help operationalizing sustainability [7] and help evaluating the usability aspects of the approaches related to it; thus, SCHI calls for a critical, yet all-encompassing approach to innovation, particularly in the technological front [8].

There are several HCI/technological developments where the solution creators try to act more responsibly and orient their efforts towards tackling sustainability grand challenges holistically [6], identifying appropriate appraisal methods for SHCI today and in the future, including ways to communicate sustainability solutions [5]. Among these approaches, there is an increased reliance on the application of persuasive systems, which in most

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instances are called eco-feedback systems [[5], [7], [9]] or "technology that provides feedback on individual or group behaviors with a goal of reducing environmental impact" ([10], p. 1999). Given their characteristics, these eco-feedback systems can be considered an environmentally focused representation of *gamification* – an intentional process designed to afford positive experiences, skills, and practices similar to those of games through any activity, system, service, product, or organizational structure [11]. However, due to their potential to affect human behavior, social and mental wellbeing, gamification and other similar approaches are often questioned as a responsible practice [[12], [13]]. SCHI research shows that eco-feedback as a persuasive system seems to reduce the understanding of sustainability as a matter of negotiations rather than informed-based change [7], and the consideration of long-term or negative impacts are largely overlooked. Therefore, in the context of SHCI, the design and implementation approaches of gamification as innovation should consider potential harmful impacts and call for inclusion of responsible practices to address the challenges inherent to bringing together different stakeholder interests.

To this end, the present study concerns itself with the value-based considerations for creating gamified sustainable consumption apps according to the dimensions of responsible research and innovation (RRI) endorsed by the European Union. Beckoning the sustainable consumption app (SCA) creators to consider their apps' intended and unintended impacts, we hypothesize that including gamification as an innovation under RRI dimensions into the app design process can contribute to a value-based design of SCA and more sustainable human-computer interaction practices. Thus, our research question is: **How can SCA creators responsibly integrate value-driven gamification as an innovation into their design and implementation processes?**

2. Theoretical background

The current HSCI literature, while calling for multidisciplinary, intersectoral participatory processes, tends to focus on the user perspective, the functionality of the designs, and their expected impacts [[4], [5], [6], [8], [9], [14], [15]]; hardly addressing the mindsets of the creators or acknowledging their individual motivations to become sustainability activists through HCI solutions. Therefore, in this study we investigated how SHCI practitioners, represented by the creators of sustainable consumption apps deal, and understand their responsibility to implement gamification as an innovation, addressing the call for practical approaches to translate responsible research and innovation from a conceptual aspiration to an implementable strategy, pointing at the need to share the reasons and methodological decisions from the early design stages [[16], [17]]. Hence, this section elaborates on the theoretical frameworks used for our research.

2.1. Gamification as an innovation

The eco-feedback activities described in existing SHCI research usually present a skewed understanding of sustainability; this is a focus on environmental impacts and it is usually applied to energy-related activities [[4], [7]]. However, the literature shows a myriad of formalized principles for the application of persuasive approaches as part of the design [4]. Considering eco-feedback systems as an expression of gamification opens a multidimensional and synergistic approach to innovation processes for SHCI since gamification can be applied through all its phases (search/ideation, selection, implementation and capture) [18].

Specifically, the existing literature on the subject portrays gamification as an innovation through three processes: i) investigation – gamification that reveals problems; ii) induction – gamification to stimulate novel behavior; and, iii) intervention – gamification that transforms processes for improved effectiveness and engagement [19].

The first type, investigation, is mainly based in co-creative processes, such as crowdsourcing, to capture information and transform it into a desired goal, for example improved health systems, or the development of more resource-efficient technologies [19]. Gamification as an induction process is meant to stimulate innovative behaviors, usually introducing fantasy elements and challenges of collaborative behavior, and it is applied to animate scientific teaching or embedding critical thinking into curricula, for example [19]. With the third type, intervention, gamification acts as a facilitator to enhance an existing function and it is largely applied in education and organizational change activities to motivate participants to engage in actions of change [19].

Regardless of their type, the gamification as innovation implementation processes often convey many layers, from correctly identifying the problem to gamify (e.g. climate change), to the capabilities of implementing a gamified strategy (e.g. having enough knowledge of gamification to design a long-term strategy). These nuances may curtail the innovation processes, posing a challenge to understanding gamification as innovation perspective, its integration potential, and overall applicability throughout the innovation process [[18], [19]]. Moreover, whether presented as eco-feedback, or as gamification, there is a constant concern about the extent that applying persuasive technologies can lead to unsustainable behaviors [7], a risk that SHCI practitioners should always bear in mind. Therefore, recognizing gamification as an innovation demands examining gamification design frameworks that enable responsible, value-driven and practice-based considerations. To make this possible, [20] encourage the creators of gamified approaches to only use systems they would be willing to be persuaded with themselves, and action that attains SCHI practitioners to acknowledge their responsibility towards the users whose lifestyles they intend to change [5].

2.2. Responsible Research and Innovation (RRI)

RRI elaborates on the notion of trust building between individuals and technological innovations, as it places societal needs at the core of research and innovation, highlighting the responsibility factors and their alignment with society's values. RRI intends to secure societal acceptance of new technologies and trust in science [21] through multi-stakeholder collaboration under principles of transparency and mutual responsiveness [22]. Moreover, RRI seeks to present innovation beyond mere technological development [23], acknowledging the existence of uncertainties and unintended consequences, which all involved stakeholders should be aware of and prepared to respond to. Although the European Union has been endorsing programs and formulating policies addressing technology-knowledge concerns for over a decade, the implementation of RRI in other spheres, such as non-for-profits, business, and corporate responsibility practices, is still in a very early stage [[24], [25]]. This situation calls for value-conscious frameworks to facilitate the integration of RRI dimensions into the design and development practices of technological innovations such as mobile apps.

In their seminal work about ethical implications for RRI in the information and technologies field, [26] categorize RRI as a "meta-responsibility" that aligns the existing network of responsibilities in the Information and Communication Technologies (ICT) sector "defining socially desirable consequences that existing responsibilities can work toward and develop responsibility relationships that ensure that the achievement of such desired aims is possible" ([26], p. 202). RRI frameworks are built on the dimensions of anticipation, reflexivity, inclusion, responsiveness, and care [[23], [27]], elements that this study proposes to integrate into the design processes of sustainable consumption apps, thus contributing to the field of sustainable human computer interaction.

[26] propose the "4P" approach to identify and engage with the ethical implications of ICT. These Ps are product, process, purpose, and people, and to fully integrate RRI into each of these, it is crucial to facilitate processes and indicators to monitor awareness, implementation, and assessment, based on RRI values and norms to facilitate their integration along the value chain [28]. On the basis thereof, value-conscious approaches to gamification design and implementation are paramount for enabling the contexts where RRI actions can take place, like in the case of mobile apps designed to help their users live more sustainably.

2.3. The Sustainable Gamification Design (SGD) framework and app users' needs

The integration of gamification into the design process, is a value-driven endeavor as these values take the shape of engagement, learning, and collaboration, shaping behaviors, empowerment, transformation, provision of analytics, and fun [29]. As such, every value is also prone to be affected by situations or issues that destroy them, for example, when using gamification as a persuasion tool, which conveys several moral and ethical challenges. To address these challenges, [29] proposed the Sustainable Gamification Design (SGD) framework, a conceptual model that introduces a frame of values and ethics to manage the potential negative impacts of gamification's value destroyers. Although originally developed to support the design of gamification strategies for organizations, the SGD is a human-based approach to gamification design that reflects the call for the ethical and responsible design of mobile apps.

[30] bring a more detailed account of the users' needs and wishes for sustainably developing apps, bearing in mind some of the risks that concern users the most. The requirements for a sustainable design of apps proposed by [30] include *attractiveness, efficiency, accuracy, and value for money*, and strongly emphasize *security and privacy*, both as a safety concern and a risk area for using any app. These concerns are reflected in each of the gamification value destroyers distinguished by [29], which are noted as gamification leading to *coercion, data leaking, channeling, norming, disempowering, misrepresenting, and providing inauthentic and shallow accounts*. These value destroyers also stand against everything RRI represents, posing a challenge to its implementation. For example, in the case of gamified mobile apps enabling sustainable consumption practices (SCA) there is no evidence of a long-term behavioral change; however, there is an overriding focus on environmental issues and plenty of gamification practices with unclear purposes [31]. Nonetheless, the benefits of applying gamification to motivate more responsible consumption practices are exemplified by improved wellbeing conditions facilitated by mobile apps purposefully designed to this end [[14], [15]]. However, they come with many cautionary tales about unintended impacts and behaviors, which attain directly to the need of implementing practices of responsibility and trust-building in the development of these apps.

3. Methods

3.1. Approach

When assessed against the framework of the United Nations Sustainable Development Goals (SDGs), the global agenda for acting today toward a sustainable future [32], most of the research about HCI and sustainability happens in the field of Responsible Consumption and Production (SDG 12), mainly addressing the management and efficient use of natural resources, and reducing waste generation [7]; thus, promoting more environmentally-friendly and, potentially, more sustainable consumption choices. Moreover, mobile applications are the most used yet emergent HCI interface to promote sustainable consumption at the individual level [[33], [34]] as they are known for functions such as marketing, entertainment, information provision, socialization, and even intellectual stimulation [[35], [36]].

Based on the definition of sustainable consumption behaviors as "individual acts of satisfying needs in different areas of life by acquiring, using and disposing goods and services that do not compromise the ecological and socio-economic conditions of all people (currently living or in the future) to satisfy their own needs" ([2], p. 5), this study considers sustainable consumption apps (SCA) as the mobile applications created to *enable individual choices that satisfy needs through different consumption stages without compromising the living conditions of people and other species today and in the future*. Despite their future orientation, SCAs often present some gamified features, ranging from badge collection and leaderboards to in-app and external rewards, and they tend to disappear five years or less after their launch to the market [31]. The changing landscape of apps for sustainability leads to questioning the values and motivations behind the existence of such apps and the challenges their creators face to make them meet their objectives. Some of these challenges include issues such as how researchers and practitioners choose their sustainable consumption narratives and gamification elements, leaving open the opportunity to refine their design strategies and deliver more comprehensive, systemic (cause-effect) understandings of sustainable consumption via gamification.

This study considers sustainable consumption apps (SCA) as mobile applications created with the intention of enabling behaviors resulting from the awareness of the impact of today's consumption activities and the future wellbeing of societies and the environment; in other words, what [2] define as sustainable consumption behaviors. Understanding RRI "as an attempt to give a procedural answer to the question of how to deal with the uncertainties around innovation" ([26], p. 203), to answer its research question, the research is framed according to [26]'s "4P's" of RRI, a framework created to highlight the purpose and the people behind the innovation and not only the product and the process, (Table 1) to identify and engage with the ethical implications of ICT in the context of gamification as an innovation.

Table 1
This study according to the 4P's of RRI

Product	Gamified sustainable consumption apps (SCA), one of the many approaches to enable SHCI that can have unforeseeable consequences.
Process	Identify SCA creators' accounts of gamification-led value destruction, exploring how these can be overcome through the integration of RRI considerations, and compare these concerns with the app users' requests and risk perceptions [30].
Purpose	Most of the studies about SCA creation have a user-centered point of view. With this study, we provide a creator perspective about the main issues of concern when implementing gamification to SCA, thus consolidating a user-creator landscape toward the responsible design of gamified SCA.
People	SCA creators presenting their accounts of identified societal consequences beyond the use of their app (interview results) Input from app users' perceived risks and requirements as presented by [30].

3.2. Data collection and analysis

To initiate the **process** of identifying the SCA creators' accounts of gamification-led value destruction and comparing their concerns with the app users' requests and risk perceptions, the first step was to select the pool of apps whose creators' opinions will be examined. The app database from an earlier study [31] allowed the selection of **the product**: 52 apps representing different stages of popularity and gamification features. The sample consisted of apps marketed in Google Play and App Store under the labels of sustainable consumption, sustainability, sustainable living, sustainable lifestyles, green lifestyles and eco-friendly living. Other keywords related to lifestyles, such as "mindfulness" or "wellbeing" were not used as they might not relate directly to consumption practices.

To enable diversity in perspectives, and fulfill the **purpose** of this study – contribute to the implementation of value-oriented, innovative design practices to advance SHCI – a pool of apps was created with the following categories, with 13 apps selected for each: i) highly downloaded and rated (most popular) gamified apps; ii) apps that disappeared through the 2021 analysis; iii) apps that had more gamification elements than the average of apps analyzed in 2021; iv) new apps that appeared in the market after the 2021 review, and apps that were not analyzed in 2021 because they were not gamified. The last group (non-gamified apps) was included to learn about the considerations for not implementing gamification. The 21 interviewees represent 2 apps from group 1; 6 of group 2; 6 of group 3; and 7 of group 4, three of which are not gamified.

The participants are considered key informants due to their close relationship to the research subject [37]. The process to contact the interviewees consisted of a) reviewing the app information available on the online platform, the app's website (if applicable) or the app itself. These channels contain the name of an organization or a person behind the app. 24 of the 27 people who replied to the invitation to join the study were contacted via their Linked-in profiles or personal email address (two of them have it as part of the apps' information), two replied to the "info"-general email address, and only one contacted us after we submitted a meeting request through their online contact form. All participants were provided with a description of the research project, the data management guidelines, and an informed consent form. In the end, 21 app creators – the **people** behind the conceptualization, implementation, and maintenance of the app, who could also be the technical developers but not necessarily – were interviewed via Zoom and MS Teams during April and August 2022. Regardless of their role in the organization behind the app, the 21 creators interviewed are decision-makers for the app's

survival, meaning they are directly responsible for its maintenance and online presence. The questionnaire for the semi-structured interviews was reviewed and validated by four topic experts, from China, Finland, Mexico, and the Netherlands, respectively. The interview guideline comprised 4 parts. The first focused on the creators' background, their understanding of sustainability and the reason for creating an app to act upon this understanding. The second part zoomed into the expected sustainability impacts of the apps and the role gamification played within, including elaborating on the notions of ethics and responsibility as a creator of a sustainability-oriented solution. The questions of the third section provided insights into the tensions and dilemmas of managing a mobile app in a highly competitive market; while the fourth section offered the opportunity to reflect on their overall learning journeys. The full interview guideline is available in [38].

After the interviews, the answers were anonymized and coded which allowed us to identify the areas of concern according to the SGD value destroyers [29]. The diverse understandings of responsibility and risks presented by the creators, compared with the user requests from [30]], also shed light on the most and least explored RRI dimensions, helping to draft what now can be used as a design guideline for SCA creators. Figure 1 summarizes the process followed for this study.

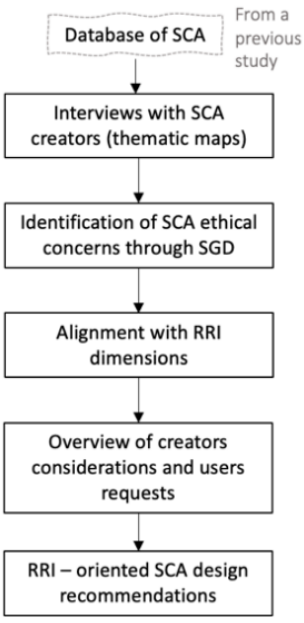

Figure 1: Research process.

4. Results

This study is framed according to the 4P approach for responsibly identifying and engaging with the ethical implications of sustainability through design via gamification as a threefold innovation; it analyzes the ethical considerations behind mobile apps created to encourage sustainable consumption practices and contribute to the growth of innovative design practices in sustainable human-computer interaction and sustainable human-computer interaction as a research field. The resulting analysis intended to emphasize the SCA creators' responsibility when choosing to implement gamification in their apps. This section showcases the findings of the interviews with 21 SCA creators, highlighting both their main concerns regarding implementing gamification and approaches to act according to the RRI dimensions to tackle these value destroyers.

4.1. Identification of SCA creators' concerns of gamification as innovation through the SGD framework

The question about approaches to persuade people to use their apps and meet their ultimate objectives helped the interviewees elaborate on why applying gamification and their choices to it related. Figure 2 provides an overview of the answers. Analyzing their accounts through the value destroyers of the SGD showed that the main concern about using gamification in SCA is related to the potential *human agency loss*, a value destroyer related to how human-computer interactions attribute agency to the computer rather than to the person, hence reducing the individual's enjoyment and autonomy, depriving the user of their freedom to make decisions. This finding is consistent with what [39] note as inhibitors of rational self-reflection that undermine the users' autonomy that lead to considering gamification as a manipulative strategy. Considering that 16 of the 21 creators indicated their apps intend to support individual choice-making, it is not surprising that their primary concern is designing apps that make people realize they have the power to choose. Nonetheless, the issue of why the app facilitated individual agency presented polarized arguments. Five creators declared their apps intend to provide information in a way that people do not feel judged or preached to, that users were willing to act and only need some guidance for their efforts; "People don't want to feel they are being told what to do or being talked down to or lectured" (creator 1). On the other hand, five creators declared that the apps were needed because users would not do anything on their own even if having information, so the app gave them an easy way to be active; "Most people are lazy, they need to be told what to do so they realize changing is not that difficult" (creator 2).

Figure 2: Gamification value destroyers from the creators' perspective

Current studies addressing the ethical aspects of gamification tend to highlight issues of data management and privacy as factors that may inhibit the uptake of gamified SHCI solutions [[40], [41]] therefore, it is not surprising that *leaky containers* was the second issue of high concern. Most creators had data management and privacy-control mechanisms in place, although they varied greatly. For example, two apps do not require signing up or registration of any sort. In contrast, others allowed registration via social media accounts, which means that the users abide by the privacy rules of these providers and not the apps. Eighteen creators claimed not to collect any personal data, having only anonymized user statistics; "We only want to see how often the app is used and where. We have a feedback form, and our users contact us constantly; sometimes they sign with their names, but we don't store these" (creator 4). Privacy was a priority focus for the apps targeting underaged users (2 apps) or involving in-app transactions (6 apps); it is also part of the value proposition for the apps partnering with companies: no individual employee data is collected, the information is all anonymized and only the company, not even the app's team, have access to it; "We provide the technical and content support, we do not collect personal information of any sort" (creator 5).

Two value destroyers were deemed equally worrisome (8 creators each); one was the *homogenization of the workforce* and the other, *creating an illusion of change*. The former is related to data collection and mining, and it is an area of primary concern for apps dealing with business partners as there is a risk that employees will be treated as having the same level of knowledge or interest in the topic, obliterating their individual motivations and experiences in the area of sustainable consumption. Moreover, this concern reiterates the notion of separate virtual and real lives, as human actions become the result of data-driven dictations [42]. However, only one app provides its partners with anonymized data about the "green consumers" so they can tailor their sustainability campaigns. While this may be a foray into the user homogenization territory, the creator noted that the app's appeal is to provide accurate data regarding time, length of actions, and location, cross-referencing it with non-identifiable information such as gender and age. *The illusion of change* was one of the main arguments for not applying gamification or doing so very lightly so as not to convey the idea that using the app was enough to drive change. This concern reflects what [43] warned about the risks of using gamification as a hook that can eventually lead to deception, or even develop addictive behaviors [[39], [42], [43]]. Eight creators highlighted the relevance to clarify to the users that the real impact happens outside the app and that gamification is just to assist them in adopting new habits. Another reason for concern is that gamification may simplify the magnitude of the problem, so users should be made aware that the small gratifications provided by the app are a recognition for their efforts to achieve a more significant, real-life goal. "A lot of apps out there have a self-declaration mechanism whereby you can sit on the sofa and say 'OK I took a 3min shower and I did great' […] with our app we are trying to make actions verifiable and fairer to all. There are certain limitations, and this is an area we are working on because we need to improve it" (creator 6). In some cases, the creators justified the use of gamification as the best way to visualize the change; "We decided to put fun first because the impact comes after people play the game […] it can happen without the app, true, but it may not be half as fun" (creator 7).

In a similar vein, the value destroyer of *coercive participation* was noted as a risk for people using the apps as part of an employee engagement strategy, as they may feel forced to join the program even though participation must be completely voluntary with no other incentive from the app than making things more entertaining and useful. In the workplace context, this risk also attains to the potential exploitation of employees [[44], [45]]. Also, two creators noted close cooperation with their partners to design the app as a part of their unique value proposition; this is because, for them, understanding the context and wishes of the partner helps to prevent implementing features that could be perceived as coercive; "We have to be very, very context sensitive. I develop apps for social causes, you can't be patronizing, and you can't just force people to play and like your app just because you've got the funding for it" (creator 8). Consistent with the warnings for implementing gamification presented by [[42], [44]], of four creators who steered clear of gamification altogether two were highly concerned about gamification providing a *shallow and unauthentic understanding* of the apps and the problems they try to address. These creators noted how the "dopamine rush" provided by gamification would distract the users from the real issue and create the sensation that things were an easy fix, and even lead to behaviors like cheating for the sake of getting the rewards rather than shifting consumption patterns; "The rewarding system […] may induce people to start cheating just to keep competing, totally missing the point of the app" (creator 9). The creators of the other 2 non-gamified apps noted not knowing enough about the subject, nor having the resources to consider gamification as relevant for their apps. Lastly, the *technological whip* was the value destroyer SCA creators are less concerned with, as this is a risk related to using gamification to maintain organizational social constructs, which does not apply to the apps not operating in an organizational environment. The creators of the seven apps involved in engagement programs declared their apps are used for corporate responsibility activities or educational programs, all of voluntary participation, presenting concerns similar to those identified by [[44], [45]].

The analysis of the SCA creators' concerns about implementing gamification through the SGD lens helped to outline some of the strategies and opportunities for contributing to RRI practices and the overall SHCI development field.

4.2. Alignment with RRI dimensions

The systematic analysis of gamified SCA of 2022 [31] called for the need to integrate socio-ethical issues into the development of SCA, expanding collaborative

Table 2
Overview of RRI integration into the app design process according to the 4P's

RRI dimension	Product	Process	Purpose	People
Anticipation	Market and stakeholder analyses	Creators to educate themselves on the topics of gamification and sustainable consumption.	Widening their understanding of sustainable consumption to provide more systemic narratives and solutions.	Target the app to specific user groups, recognizing their needs, level of knowledge, and reaction to gamification
	Risk identification and management plans.	Revisit the app's value proposition.	(Re)consider if gamification is an approach that would work for their app and its users.	
	Reviewed value proposition plans	Identify potential risk areas for all stakeholders		
Reflexivity	Strategy-review meetings with management and extended teams (i.e., subcontractors)	Keep updated with regulatory frameworks	Consider unexpected impacts and risks related to launching an app	Involve users in prototyping stages.
	Feedback loops	Incorporate user and partners' feedback through several test rounds.		Request input from subcontracted partners according to their expertise.
Inclusion	Open presentation of values, vision, and mission of the app	For individual creators, these activities are about publishing their motivations and work principles.	Create a continuous flow of information between SCA creators and their stakeholders	Collect and act upon the user feedback. All team members should be part of this enterprise.
	Public Code of Conduct Consultation rounds beyond users' ratings in app stores	Pairs and teams need to co-create these visions and codes of conduct, also discussing the stakeholders' feedback and incorporating it.		Present the app's identity to partners and sub-contracted parties, inviting them to find affinity areas.
Responsiveness	Communication channels	Establish clear communication mechanisms and answer them.	Constant communication with the user and adaptation to their needs.	If possible, involve a third party to certify the content of reports. If the costs are too high, consider user-based validation as an option.
	Reporting mechanisms	Set up reporting processes to keep all stakeholders informed about issues of their concern.	Establish clear indicators and times for reporting.	
Care	Feedback loops	Besides visiting the store ratings and users' comments, the app can include an email address to contact or even an in-app experience rating sheet.	Keep an open channel and reply / act within a reasonable time, even if it's to note that acting will take longer than expected.	Acknowledge and thank all the feedback provided – even when irrelevant to the app.

efforts among societal stakeholders and distributing both the agency and responsibility to enable sustainable consumption practices. To align with the dimension of *anticipation* or envisioning future research or design from current dynamics [23] SCA creators should consider their apps' unintended and potentially harmful results. The SGD fully embraces this dimension at the beginning of the process, asking designers to review their values and ethics as their first step, thus directing the visioning and exploration of technological platforms according to the creators' values and the users' needs. Although some creators already have risk management plans in place, some struggle to identify these risk areas when it comes to implementing gamification; in many instances, this is due to their limited knowledge about gamification.

The dimension of *reflexivity* relates to the values and beliefs of the actors involved in science, public collaboration, and dialogue [23]; it is needed for creative problem-solving and engaging other stakeholders in the design process. Almost all interviewees claimed their apps were inspired by their own needs and those of their immediate circles, involving their users in the prototyping stages – one app was even developed in a living lab environment – incorporating their feedback and creating learning loops to meet their users' needs besides keeping consistent with their values and objectives. Besides being a practice of reflexivity, creating these feedback loops is also a contribution to the *inclusion* dimension, which is about identifying socially desirable outcomes from the perspective of all stakeholders involved. An all-encompassing take on this dimension may help SCA creators to strengthen their apps not only through feedback but also with codes of conduct clearly presented to their users and partners, overcoming mismatching expectations, such as expecting apps to be entirely free of use even though the sustenance of the creator may depend on the app. This dimension also attains collaboration with experts and individuals from other industries and sectors. All RRI dimensions are interconnected, and *responsiveness* is a natural companion to inclusion. While mainly related to the mid and long-term risks of new technologies, this dimension is also about transparency and accessibility so that all stakeholders are aware that gamification is a long-term investment that requires maintenance and updates. Reporting on the app's performance and presenting the creators' code of ethics encourage users and potential partners to see their affinity with the app and their eventual uptake. [23] also elaborate on the dimension of *care*, or the human capacity to decide and judge where individuals take responsibility for decisions and actions carried out on their behalf. Care is differentiated from inclusion because it looks into the human as an inner decider who does not want to be judged yet needs support to act, as noted by some of the SCA.

Error! Reference source not found. presents an o verview of how SCA creators can embed RRI dimensions into their design and management processes. The products enlisted are part of the ICT creation ecosystem facilitating RRI practices.

5. Discussion

This study set to explore the main concerns of SCA creators when implementing gamification as an innovation that investigates, induces, and intervenes in consumption practices, depicting how RRI dimensions could be integrated into the design and implementation processes of these apps; thus, contributing to innovation in SHCI and SCHI as a research field in general. To this end, the analysis departed from the higher understanding that ICT is "any high-level socio-technical system that has the potential to significantly affect the way humans interact with the world" ([26], p. 204); therefore, the creators of ICT solutions should be able to understand the capabilities and constraints of technologies as they emerge, as this helps to foresee what could be done today to ensure that the social and ethical consequences of technologies are not detrimental to humans or the environment. Part of this understanding conveys knowledge of what their users consider a risk besides what they need. While the apps may have very specific target users (e.g. the communities where they operate, or the employees of their corporate partners) in general, they all aim at engaging users willing to live more sustainably, supporting their efforts to do so. Therefore, we used the results of [30] to align the creators' considerations and users' requests to guide the discussion about the elements of concern to gamify SCA responsibly through the RRI dimensions.

5.1. Users' requests and perceived risks

Users' request 1 – Monetary aspects

Price and value for money. This area represents the widest gap between the users' requests and the creators' concerns. [30] elaborate on how the cost of an app influences its perception and attractiveness for downloading. In the case of SCA, the creators expressed the presence of a pervasive notion that sustainability-related apps for individual use should be free, leaving the creators needing other income-generation means to keep the app working and relevant. While gamified apps seem to be more attractive and last longer than their non-gamified counterparts [31], gamification comes with a higher price tag, as the creators need to keep up with the costs behind the strategy and its implementation, as well as come up with coherent gamification strategies, hopefully steering clear from physical rewards that convey additional charges. In general, balancing the costs with the users' expectations attains all the value destroyers, as a botched gamification strategy might as well lead to the app's disappearance. Enabling inclusion and responsiveness practices in the design process has helped the creators to identify their users' needs, and it should also be a channel for the users to understand the creators' plights for maintaining the apps and delivering the value they are looking for. All the accounts of the five app creators whose apps disappeared pointed to financial woes as one of the main reasons. The creators behind the five apps that

switched business models from servicing individual consumers to partnering with businesses expressed a similar situation for their choices to keep their app alive, even if that entailed curtailing their work for the free versions of their apps and reaching narrower audiences. Thus, enabling user awareness about the actual costs of the apps should be part of the creators' responsibility, instilling the dimension of care and advancing RRI awareness and implementation processes. It should also be part of the users' responsibility. Part of this narrative should emphasize how shifting consumption practices today may seem costly, but the price to pay tomorrow is even higher if remaining inactive.

Users' request 2 – Ease of use

This rubric comprises notions related to the apps' efficiency, attractiveness, usability, learnability, and comprehensibility. Elements that gamification can contribute to bringing forward if adequately implemented. For the creators, these notions are the core of their value proposition and, sometimes, the reason not to team up with third-party advertisers, for example. Recognizing that their apps are mainly used on phones with limited screen space, seven creators elaborated on the importance of maximizing the screen space with relevant information and features rather than adding unnecessary noise that may deter users from exploring the app or staying loyal to it. Considering the users' experience is an example of both anticipation and reflexivity, as the creators find a way to communicate the intention of their apps in a more straightforward and transparent manner than under layers of text or hidden functions. The value destroyers of human agency loss and homogenization are the ones most likely to emerge if the app creators do not pay the same attention to these user requests. There is no one-fits-all approach to gamifying SCA; thus, the creators should take enough time to plan the gamification project before proceeding with the rest of the design process [46], mainly if they will involve other stakeholders as the RRI dimensions of inclusion and reflexivity require.

Users' request 3 and number 1 perceivable risk – Safety aspects: privacy and security

The leaky containers and coercive participation value destroyers are the most likely to emerge if the creators do not have clear guidelines for safely collecting and managing their users' data. The RRI responsiveness dimension suggests creating a transparent code of conduct and enabling transparent accountability mechanisms. These practices attain RRI awareness and implementation and to the assessment activities, as all stakeholders have access to the app's creators' code of conduct, not only to their visions and value statements as organized entities. The convergence of risk perception and requests from the users' side is a clear indicator for the creators about what areas should be prioritized and clearly communicated. Moreover, developing performance indicators in this regard can help strengthen their presence and confidence among potential partners. While some of the interviewed creators had comprehensive risk plans, the reliance on the app store's safeguards may not be enough guarantee for users; therefore, the creative teams behind the apps should plan strategic sessions to consolidate their risk assessment and management plans, keeping them flexible enough to adapt to the development of technology, changes in regulations, and changes in the market, thus enhancing the dimension of anticipation too.

User perceived risks 2, 3 and 4 - user-friendliness, pleasure of using the app and accuracy

Here, the value destroyers *illusion of change* and *shallowness* indicate a dangerous zone for the app creators if they do not manage to provide gamification elements consistent and coherent with what the app stands for. As the app analysis [31] revealed, many apps with high volumes of downloads and reviews rely on out-of-app rewards in the shape of discount vouchers that can be used for more consumption. While this mechanism is presented as a "win-win" situation for the user and the planet, this gamification system leads to using the app for immediate, personal gratification instead of adopting sustainable consumption habits. Such situations directly confront the RRI dimension of care, as the users' trust in someone making decisions for them, in this case, the app is misleading the intention to consume better with fewer resources.

The perceived risk of accuracy is also a milestone for the design of SCA. 12 creators noted how much of their resources were invested in research and the provision of reliable data. The apps created to provide information for choice-making have several guidelines for acquiring and curating information before it is made available in the app. The creators are well aware of the damage that providing false information would convey and often rely on the feedback of their users to improve their content. This activity is part of the RRI domain of inclusion and reflexivity; as the creators check if the data is correct, reliable, and relevant to what the app stands for before including it as part of their content. Thus, the gamification elements should be able to reinforce the understanding that the information presented is accurate.

Although the germinal processes, resources, and motivations to embark on an SCA creative journey vary, the people behind these apps can consider the recommendations below as an opportunity to contribute to practices of sustainable human-computer interaction responsibly.

1. Define their sustainability values and ethical stances as a prerequisite for topical, marketing research, and decision-making by:

- Developing a unified description of their sustainability values and using it for envisioning risks to create strategies to manage these (e.g., coming up with potential unintended negative impacts they can mitigate). Reaching out to potential users and investors can help define their sustainability stances and draft solid risk management plans;
- Educating themselves on sustainability and gamification topics to find suitable strategies and include relevant in-app content (e.g., learning about the true costs of developing gamified apps; and avoiding rebound effects based on physical rewards);

- Conducting appropriate market and user analysis (e.g., for tailoring gamification aspects and in-app content to the right audience).

2. Enable creative problem-solving through participatory design:

- Involving users and all other relevant stakeholders throughout the development process (e.g., including diverse perspectives for improved app usability);
- Considering the users' opinions and experience by asking and addressing feedback in all stages of the development and use (e.g., for providing relevant and accurate content only, for transparent and straightforward communication of app intention).

3. Implement holistic approaches and cross-cultural cooperation for socially desirable outcomes:

- Elaborating a code of conduct based on the defined sustainability values and ethical stances;
- Deploying cross-sectoral collaboration and involving experts of different sectors adhering to the code of conduct, for a better and more relevant representation of the topic; for enhanced adoption of sustainable consumption behaviors; and, for developing a holistic approach yielding generalizable socially desirable outcomes;
- Creating and managing realistic expectations of all parties (e.g., financial management of the app);
- Enabling transparency in processes and safety guidelines/codes of conduct (e.g., transparent communication that delivers value; public information about app's values; and transparency in data privacy and security).

4. Develop and maintain responsiveness strategies for transparent communication and accessible solutions:

- Elaborating practical and accessible communication channels (e.g., for making the process of leaving feedback appealing to the user, thus contributing to a more desirable app);
- Implementing effective reporting mechanisms, including report validation (e.g., for establishing and nurturing regular and transparent communication with the stakeholders; for ensuring correct and digestible reports);
- Considering and addressing user feedback in a prompt manner (e.g., for maintaining users' engagement and development of user-friendly and accessible solutions).

5. Nurturing a sense of shared responsibility between app creators and users:

- Make the code of conduct, sustainability values, and ethical stances public to the users;
- Building and maintaining relationships with users and other stakeholders through shared efforts (e.g. for long-lasting partnerships; for avoiding human agency loss among users; and for achieving common sustainability goals).

5.2. Contributions and way forward

The above discussion points illustrate how this study contributes to sustainable human-computer interaction by providing SCA creators with recommendations to support their apps' objectives while bearing unintended consequences in mind, particularly if applying gamification. As most of the creators provided accounts highlighting their focus on the *care* dimension, since their apps are enablers of personal change, they need to reflect on the messages they are conveying through their apps, and the responsibility of offering a tool for individual behavior change brings about. This paper contributes to the studies of SHCI through design, presenting how integrating RRI dimensions into the design of gamified sustainable consumption apps may help advancing digital societies from a value-based approach to innovation. The postulates of this study also entail many limitations, like the size of the sample. Though sustainable consumption apps are a very specific niche, the results presented are based on the qualitative analysis of the accounts of 21 individuals. Also, none of the analytical frameworks used was purposely designed for mobile apps, although both relate to the study's subject; the 4P's are considerations for RRI in the ICT sector, while the SGD is about value-based gamification design. Perhaps developing our own framework with the themes that emerged from the data, or using other frameworks specifically created for SCA would yield additional results; these options were not explored due to the size of the sample and the time restrictions inherent to this study. Another existing issue is the applicability of the recommendations hereby presented. Although on paper, they seem straightforward, in practice, SCA creators may encounter many obstacles to implementing them, from the time available to carry out these processes to the costs of maintaining any additional features or involving more people in activities beyond their job descriptions. These recommendations intend to add value to the SCA, and the creators are invited to consider the ones that represent a low-hanging fruit according to their current reality. Another limitation comes in the shape of the users' requests and perceived risks, as the analysis was done referring to existing academic research instead of interviews with the users of the apps, which could help depicting more specific request for the creators to heed. After reviewing similar studies, the chosen one represented the most comprehensive and updated overview of users' needs. Including other similar studies may help to provide more robust findings. Nonetheless, the novelty of this research lies in its value-based approach to identify and embed the app creators' considerations for ethically applying gamification within the RRI dimensions, helping to narrow the gap between studies focusing on app design from the user experience and those seeking examples of RRI in practice.

6. Conclusion

As the use of apps for everyday activities keeps growing, so does the studying of how apps function and what users require so that app creators can operate and survive in an increasingly competitive field. When it comes to sustainability by and through design, ICT solutions have a strong orientation toward consumption and production practices. This study focuses on the consumption aspect, as the narratives related to it vary enormously, and so do the apps created with the intention of enabling behaviors that contribute to it. While existing research corroborates the inclusion of gamification as a part of the design efforts to promote the efficient use of resources and positively impact the environment, there is less information about what considerations the creators have about the unintended effects that their apps may have. This study emphasizes sustainability through design by proposing a values-based approach to designing sustainable consumption apps, recognizing gamification as an innovation that reveals problems, stimulates novel behaviors, and aims at transforming processes for improved effectiveness and engagement. In addition, this study highlights that utilizing gamification as an innovation strategy in SHCI, not only helps to address many of the shortcomings of eco-feedback systems but could result in both socially desirable and undesirable consequences, drawing attention of SCA creators to potential risks and calling for their preparedness to prevent or mitigate them as part of their apps' value propositions.

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