

Article

Influenced by Design—How Design Cues Can Shape Sustainable Design and Evaluation Choices

Olga Levina , Aleksandra Revina *  and Friederike Lindauer 

Department of Business and Management, Brandenburg University of Applied Sciences, Magdeburger Str. 50, 14770 Brandenburg an der Havel, Germany; olga.levina@th-brandenburg.de (O.L.); friederike.lindauer@th-brandenburg.de (F.L.)

* Correspondence: aleksandra.revina@th-brandenburg.de

Abstract

Digital technologies play a dual role in sustainability transitions: they can enable more sustainable practices while simultaneously reinforcing unsustainable patterns of use. Although design is increasingly recognized as a critical lever for steering sustainability-oriented behavior, little is known about how users perceive and prioritize sustainability design cues when these compete with functional, performance-oriented, and hedonic cues. Thus, this study examines how digital design cues shape sustainability-oriented decision-making by analyzing participatory design data from 18 sustainability-focused workshops with secondary-school students. Drawing on an affordance-based analytical lens, we conducted an affordance-oriented qualitative content analysis of 109 digital product concepts and 374 peer evaluation statements using an iterative coding procedure to identify sustainability affordances and competing affordances and examine how they are prioritized during evaluative judgments of digital product concepts. The findings reveal distinct context-dependent shifts in affordance salience. While sustainability affordances were most prominent in prototype concepts, where they accounted for 58% of all sustainability-related codes, they declined to 32% in positive evaluations and 10% in negative evaluations. Conversely, functional and performance affordances gained prominence during evaluative judgments. These patterns indicate that affordance salience varies across contexts and help explain why sustainability considerations may become less salient in evaluative decision settings. Interpreting these patterns through the concept of affordance competition, the study shows how multiple perceived action possibilities simultaneously compete for attention. By applying an affordance-based perspective to digital sustainability, the study contributes to research on sustainability-oriented design by highlighting how competing affordances shape the visibility and evaluation of sustainability considerations across different contexts. The findings offer practical implications for designing digital artifacts that make sustainability affordances more visible, meaningful, and competitive in everyday decision contexts, particularly for future generations of users.



Academic Editor: Mariana Petrova

Received: 28 May 2026

Revised: 6 July 2026

Accepted: 14 July 2026

Published: 16 July 2026

Copyright: © 2026 by the authors.

Licensee MDPI, Basel, Switzerland.

This article is an open access article distributed under the terms and conditions of the [Creative Commons Attribution \(CC BY\)](https://creativecommons.org/licenses/by/4.0/) license.

Keywords: digital sustainability; design cues; affordances; affordance competition; participatory design; sustainability-oriented design

1. Introduction

Digitalization has become a defining driver of economic and societal transformation. Digital platforms, services, and data infrastructures enable new forms of value creation

while simultaneously amplifying energy consumption, electronic waste, and social inequalities [1]. Hence, digitalization is increasingly understood as an ambivalent driver of sustainability transitions, capable of both enabling and undermining long-term societal goals [2,3]. This ambivalence has been conceptualized as the sustainability–digitalization paradox [3–5], i.e., digitalization can both advance and threaten sustainability goals. For example, cloud computing and data analytics optimize logistics and resource flows but also expand the carbon footprint of data centers [6]. Artificial intelligence contributes to environmental solutions such as climate modeling, energy optimization, and resource forecasting [7,8] but simultaneously demands immense computational power and energy for model training [9,10]. These tensions illustrate a central challenge of contemporary digitalization: aligning technological innovation with long-term environmental and social responsibility.

Existing research has addressed this challenge primarily at the organizational and systemic level, focusing on digital responsibility strategies, ESG (Environmental, Social, and Governance) performance, and green IT infrastructures [11,12]. While this work has generated important insights, sustainability outcomes are also shaped through everyday interactions between users and digital artifacts. Individuals repeatedly make micro-level decisions, such as configuring devices, updating apps, adjusting settings, and repairing or discarding hardware, that cumulatively influence environmental outcomes. Although such decisions are deeply intertwined with technological design, we still know little about how users perceive and respond to sustainability design cues in digital products, or how these cues compete with functional, performance, hedonic, and convenience-oriented cues that dominate contemporary interfaces. In this study, design cues refer to perceivable manifestations of product features that attract users' attention and shape how they interpret the action possibilities offered by a digital artifact. Thus, design cues are distinguished from affordances, which denote the perceived action possibilities emerging from the interaction between users and digital artifacts.

Furthermore, most sustainability-oriented research in the digital domain continues to emphasize technology adoption, organizational governance, or policy-level interventions [3,13]. What remains underexplored is how users perceive and evaluate sustainability design cues and competing design cues in digital products.

Research from Human–Computer Interaction (HCI) and environmental psychology confirms a persistent sustainability-value gap, i.e., even individuals who value sustainability may opt for less responsible choices when design cues emphasize speed, pleasure or novelty rather than responsibility [14–16]. Consistent with the broader attitude–behavior gap and value–action gap literature [16,17], the term sustainability-value gap is used here to refer to this discrepancy in the specific context of sustainability affordances and competing affordances in digital product evaluation. This suggests that sustainability-oriented digital decision-making requires examining how design shapes users' evaluations and judgments and how different design cues become salient in decision contexts [18]. Digitalization is increasingly understood not only as an enabler of technical innovation but also as part of broader socio-technical transitions toward sustainability. This dual role situates design at the intersection of material innovation and sustainable practice [19,20]. Beyond motivational explanations, this study explores whether the gap may also be partly explained by context-dependent shifts in affordance salience—that is, whether sustainability design cues that are prominent during design become less perceptually visible during evaluation.

Young users provide a particularly revealing lens for studying this phenomenon. They are among the most intensive users of digital technologies and represent future consumers, citizens, and decision-makers whose practices will shape long-term sustainability trajectories. Empirical studies indicate that adolescents express strong environmental concern

but still favor convenience and entertainment in their digital choices [21,22]. Studies of digital platforms reveal how technical and visual features (ease of use, aesthetic appeal) strongly influence young users' behavioral intentions in ways that may sideline sustainable options [23]. Investigating how they interpret and prioritize sustainability therefore provides insights into how sustainability considerations are weighed against competing design priorities in digital contexts.

Against this background, this study examines how users navigate trade-offs between sustainability considerations and competing design demands in digital artifacts. Rather than focusing on market adoption or organizational governance, the study adopts a user-centered and future-oriented perspective that highlights design as a critical leverage point for shaping sustainability-oriented decision-making. Sustainability is understood here in its environmental, social, and economic dimensions [24] and is examined in relation to design cues associated with usability, convenience, and perceived innovativeness. Accordingly, the study addresses the following research question: How do digital product design cues influence the way users evaluate and prioritize sustainability in decision-making contexts? In this study, design cues are examined through an affordance perspective [25–28], whereby perceivable product characteristics are interpreted in terms of the action possibilities they make salient to users during evaluation.

To explore this question, we analyze data from 18 Prototyping Sustainability—Designing Sustainable IT (ProS) workshops in which secondary-school students co-designed and evaluated sustainability-oriented digital product concepts. These participatory settings function as exploratory micro-contexts in which future-oriented digital practices are imagined, discussed, and assessed. To distinguish between the theoretical and empirical levels of analysis, this paper uses the term digital artifact to refer to the general theoretical object of study—that is, any digital product or system considered from an affordance perspective. The terms digital product concept and prototype concept refer to the conceptual artifacts created by participants in the ProS workshops and constitute the empirical units analyzed in this study. Unless otherwise specified, the term digital product refers to commercial or real-world products. The dataset comprises 109 digital product concepts (prototype concepts) and 374 peer evaluation statements, reflecting participants' dual roles as designers and evaluators.

To interpret how users perceive and prioritize competing design cues, the study draws on affordance theory [25–28] which conceptualizes technologies as offering perceived action possibilities relative to users' goals and capabilities. Sustainability affordances refer to perceived possibilities for environmentally or socially responsible action [29]. Although many digital systems embed such affordances, they often remain unnoticed or unused. We interpret these patterns through the concept of affordance competition [30,31]: multiple design cues within an interface (e.g., “save energy,” “customize instantly,” “upgrade now”) compete for perceptual salience and cognitive priority. Users tend to favor affordances that are visually salient, emotionally rewarding, or cognitively effortless [31–35]. Sustainability affordances, in contrast, frequently lack such attributes and are overshadowed by hedonic or performance-oriented cues [34].

By analyzing how young participants design and evaluate digital product concepts, this study contributes to Information Systems (IS) research on digital sustainability in three ways. First, the study provides empirical evidence on how sustainability affordances and competing affordances are perceived and prioritized across design and evaluative contexts. Second, it demonstrates the usefulness of an affordance-based perspective for interpreting context-dependent shifts in affordance salience between design and evaluation activities. Third, it contributes empirical insights from participatory design workshops that reveal how sustainability considerations are articulated and negotiated among young users.

The remainder of the paper is structured as follows. Section 2 reviews the state of the art on the sustainability–digitalization paradox, participatory design, affordance theory, and affordance competition, and establishes the conceptual foundations of the study. Section 3 develops the analytical framework by introducing affordance competition as the guiding analytical lens, outlining the derivation of sustainability affordances, and formulating literature-derived propositions that guide the empirical analysis. Section 4 describes the research design, data collection, and analytical procedures. Section 5 presents the findings, Section 6 discusses the results and their implications for digital sustainability research and practice, and Section 7 concludes the paper.

2. State of the Art and Conceptual Foundations

This section reviews the state of the art in sustainability–digitalization research, participatory design, and affordance theory and identifies the conceptual foundations relevant to the present study. Together, these perspectives provide a lens for examining how sustainability affordances and competing affordances are perceived, interpreted, and evaluated in digital product contexts. The section first outlines the sustainability–digitalization paradox as the broader socio-technical context, then positions participatory design as a setting in which sustainability considerations become observable, and finally develops an affordance-based perspective for analyzing how users perceive and prioritize sustainability-related action possibilities.

2.1. The Sustainability–Digitalization Paradox

Digitalization simultaneously supports and threatens sustainable development, creating what Information Systems scholars describe as the sustainability–digitalization paradox [3–5]. This paradox reflects a classic performing tension [36] in which organizations and societies pursue multiple, conflicting objectives: technological innovation and environmental responsibility. Digital systems can optimize energy consumption, reduce paper use, and enable remote collaboration. At the same time, they rely on energy-intensive infrastructures and resource-heavy hardware [6,37]. This paradox is reflected in what [38] identify as *Jevons' paradox*, or the *rebound effect*, whereby efficiency gains achieved through digitalization can lead to increased overall resource consumption when cost reductions or convenience stimulate additional usage.

While IS scholarship has richly explored organizational responses, for example, green IT infrastructures, ESG reporting, and digital responsibility frameworks [13,39], the micro-foundations of this paradox remain under-examined. Everyday digital choices such as upgrading devices, managing data, or enabling eco-modes aggregate into macro-level sustainability outcomes. Understanding the perceptual and evaluative processes that shape such decisions is therefore crucial. Moreover, work on sustainability transitions underscores the need to connect present design decisions with long-term sustainability pathways and transition frameworks [20].

Taken together, the sustainability–digitalization paradox highlights that sustainability outcomes are shaped not only by technological infrastructures and organizational strategies but also by everyday interactions with digital technologies. While prior research has predominantly examined sustainability challenges associated with digitalization through organizational, governance, and system-level perspectives [3,5,11,13,39], less attention has been paid to how sustainability considerations are perceived and evaluated in relation to competing design priorities at the user level. This study addresses this perspective by examining how sustainability affordances and competing affordances are prioritized in digital product contexts.

2.2. Participatory Design as Value-Reflective Setting

Participatory design (PD) offers a research environment where such micro-level reasoning can be observed. PD emphasizes inclusion, creativity, and shared ownership of design outcomes [40]. PD has been widely applied in sustainable design contexts to surface value tensions and catalyze systemic change [41,42]. From a theoretical standpoint, PD aligns with sensemaking theory [43]: participants construct meaning through iterative dialog and reflection.

In the ProS workshops, participants act both as designers creating prototype concepts and as evaluators assessing peer ideas through simulated buying decisions. This dual participation mode generates a dataset that captures how participants identify and evaluate sustainability design cues in digital prototypes. Recent research on youth PD in sustainability contexts shows that involving adolescents in co-design activities can foster sustainability learning, future-oriented thinking, and the articulation of transition visions, positioning participatory settings as formative spaces for imagining and evaluating sustainable socio-technical futures [44].

Accordingly, PD provides a particularly suitable setting for examining how sustainability considerations are articulated, discussed, and evaluated. By capturing both prototype creation and peer evaluation activities, PD provides the possibility for the observation of how sustainability affordances and competing affordances are interpreted and negotiated by young users. In this way, it offers an empirical context for exploring the role of sustainability in digital product evaluation.

2.3. Affordance Theory: Perceived Possibilities for Actions

Originally introduced by [26] as the action possibilities an environment offers relative to an actor's capabilities, the concept has been adapted in Information Systems to explain how digital artifacts enable, constrain, and mediate user behavior. Foundational IS work conceptualizes affordances as relational and emergent, arising through users' goals, material features, and social contexts [25,27,45].

To clarify the relationship between design and affordances, we use the term design cue to denote a perceivable feature or characteristic of a digital artifact that attracts users' attention and informs their interpretation of potential action possibilities. Design cues may relate to interface elements, functional characteristics, performance attributes, sustainability features, social signals, economic considerations, or innovation aspects. From an affordance perspective, these cues constitute the observable manifestations through which users infer what actions are possible, desirable, or valuable in a given context. When design cues are interpreted in terms of the sustainability-related action possibilities they make available to users, they are conceptualized as sustainability affordances. Throughout this paper, the term design cue is preferred when referring to the perceivable manifestations of product features, whereas affordance denotes the perceived action possibilities emerging from users' interactions with digital artifacts. The term sustainability design features is used only when referring to observable product characteristics prior to their affordance interpretation. The terms design feature and product feature are occasionally retained where they better reflect the context, established terminology in the cited literature, or the wording used by participants.

This relational perspective highlights why sustainability design cues may or may not influence how users evaluate digital products: an eco-mode, repair reminder, or privacy-friendly data setting affords sustainable action only if a user notices it and interprets it as meaningful in the given situation [29]. Affordances thus provide a conceptual lens for linking digital design with human agency and for analyzing how young users derive value from particular design cues. Prior work demonstrates how digital affordances can enable sustainable practices [46], reinforcing the relevance of affordances in sustainability-oriented design contexts.

2.4. Sustainability Affordances and Affordance Competition

Building on these insights, sustainability affordances can be defined as perceived possibilities for environmentally, socially, or economically responsible action (Kaaronen, 2017 [29]; Seidel et al., 2013 [46]). Design's role in enabling sustainable futures is also evident in materials-oriented and socio-technical frameworks that seek to integrate sustainability across multiple scales, underscoring that design choices, whether at the level of artifacts, interfaces, or systems, can shape broader transition pathways [19,47]. In practical terms, sustainability affordances may be conveyed through various design cues, such as how features that promote repair, reuse, or energy efficiency address environmental goals [48,49]; features supporting inclusivity or ethical data use contribute to social sustainability [50]; and design attributes such as product longevity or transparency foster economic responsibility [38]. When users perceive such affordances as actionable and relevant, digital systems can promote more responsible behavior.

However, users seldom encounter sustainability affordances in isolation. Interfaces simultaneously present multiple affordances that compete for attention, for example, share instantly, upgrade now, save energy. The decision of which action to take can be interpreted through the concept of affordance competition [30], whereby alternative affordances compete for salience within the user's perceptual field. Empirical studies in Human–Computer Interaction demonstrate that visual prominence, feedback timing, and reward anticipation strongly shape which affordances are actualized [31,51,52].

From a sustainability perspective, this interplay generates persistent value tensions [14,16,17]. Consistent with the attitude–behavior gap and value–action gap literature [16,17], users endorse sustainability in principle yet prioritize convenience, innovation, or aesthetics in practice. Understanding affordance competition provides a theoretical and conceptual lens for examining why sustainability considerations may become less salient when users encounter competing design priorities [14,53,54]. This lens will guide the interpretation of the evaluation data: how co-designers, acting as simulated consumers, make their choices among competing design attributes. Together, affordance theory, sustainability affordances, and affordance competition provide the conceptual foundation for the present study. This perspective emphasizes how users interpret, prioritize, and evaluate perceived action possibilities in relation to their goals and the context of use. In the present study, this conceptual lens is used to examine how sustainability affordances and competing affordances vary in salience across prototype creation and evaluation activities, and how these differences are reflected in participants' evaluative judgments. The next section builds on these conceptual foundations by developing the theoretical propositions and analytical framework that guide the empirical analysis.

3. Analytical Framework and Theoretical Propositions

The previous section reviewed the state of the art and established the conceptual foundations relevant to this study, including the sustainability–digitalization paradox, participatory design, affordance theory, and affordance competition. Building on these perspectives, this section synthesizes the reviewed literature into a set of literature-derived propositions that guide the empirical analysis. The propositions translate existing insights into analytically informed expectations for examining how sustainability affordances and competing affordances are perceived, evaluated, and prioritized in digital product concepts and evaluative judgments. From a methodological perspective, they provide an analytical lens for interpreting the coded workshop data. Affordance competition serves as the overarching analytical perspective through which the empirical findings are interpreted.

3.1. Affordance Competition and the Saliency of Sustainability in Participatory Digital Design

Building on the state of the art and conceptual foundations presented in the previous section, affordance competition is used here as an analytical perspective for examining how sustainability affordances and competing affordances are perceived, evaluated, and prioritized in digital product contexts. The central assumption is not that users respond equally to all available affordances, but that different affordances vary in saliency depending on contextual, perceptual, and evaluative conditions.

In the context of digital sustainability, this perspective is particularly relevant because sustainability affordances frequently coexist with functional, performance, hedonic, social, and economic affordances. Prior research suggests that the design cues associated with different affordances differ in their visibility, immediacy of reward, and perceived relevance [31,34,52,55], which may influence how users prioritize alternative action possibilities during evaluation [14,16,29]. Participatory design settings such as the ProS workshops provide an opportunity to examine these dynamics because participants engage both in designing digital product concepts and evaluating the concepts created by others. This dual role makes it possible to explore how affordance saliency varies across reflective design and evaluative contexts.

3.2. Deriving Sustainability Affordances

To derive potential sustainability affordances, we followed the modified design-for-affordances framework proposed by [56]. We first defined the IT artifacts under investigation, namely smartphone, website, and app. We then applied the three dimensions of sustainability [24] to classify product features according to their potential impact on one or more dimensions, and used the SDGs to situate the function–task interactions within a broader sustainability context [56].

To define the relevant tasks and required functions, we adopted a design thinking approach and developed personas together with their requirements for interacting with the artifacts. These requirements were translated into classical product features and subsequently analyzed in terms of their sustainability affordances, that is, the sustainability-related action possibilities made available through these design cues.

Because product features can be realized through different technical implementations, this process resulted in a set of design cues describing the technological features of the artifacts and their realization across different sustainability foci. These design cues were then clustered into artifact-specific catalogs and are provided together with the persona definitions in the Zenodo data repository. In this sense, the design cue catalogs correspond to the affordance repositories proposed by [56] and can be reused by designers.

This affordance-oriented perspective provides the conceptual basis for the following literature-derived propositions, which guide the empirical analysis.

3.3. Theoretical Propositions

Synthesizing these insights, we derive three propositions specifying how sustainability affordances may be perceived, evaluated, and prioritized when users encounter competing design cues. These propositions provide theoretically grounded expectations that guide the analysis of the ProS workshop data.

P1—Perceptual saliency disadvantage of sustainability affordances: Sustainability affordances are often present in digital product designs but exhibit lower perceptual saliency than functional, performance, or aesthetic affordances. In visually dense digital interfaces, immediately engaging cues, such as personalization, convenience, or aesthetic enhancement, tend to dominate users' attention. Sustainability design cues, in contrast, often lack strong visual markers or require interpretive effort, reducing the likelihood of being noticed [31,55].

P2—Dominance of immediate functional and hedonic rewards: Affordances associated with immediate functional or hedonic reward are prioritized over sustainability affordances. Hedonic and performance affordances promise direct, tangible benefits, for example, speed, convenience, novelty, or enjoyment, that typically dominate moment-to-moment judgments. Even when users hold pro-sustainability attitudes, these immediate experiential design cues tend to override more abstract or delayed sustainability benefits [14,16].

P3—Reflective amplification in participatory contexts: Participatory reflection can enhance the visibility and perceived desirability of sustainability affordances by prompting users to interpret them more consciously and critically. Sensemaking and value-sensitive design research suggests that such reflective engagement can increase the interpretive richness and relevance of sustainability affordances [40,57].

These propositions translate the conceptual foundations into analytical expectations linking design cues, affordance salience, and reflective interpretation. P1 and P2 articulate analytical expectations that can be explored in the workshop data, namely how sustainability affordances compete with more salient hedonic and performance-oriented cues. P3, in contrast, represents a theoretically grounded expectation that is more difficult to assess directly with the available data. While participatory reflection may heighten the visibility and interpretive richness of sustainability affordances, the present study can only provide indirect indications of such processes. Future research could therefore examine more systematically the specific reflective processes and conditions under which sustainability affordances become more desirable or actionable.

4. Sustainability Design and User Perception: Research Methodology

This section outlines the methodological approach adopted to examine how sustainability design cues shape user perception and evaluation in participatory contexts. Building on the theoretical propositions in Section 3, the methodology combines a design-based multiple-case study analysis with qualitative content analysis of workshop data.

Rather than aiming to capture revealed market behavior, the methodological design is intentionally exploratory and future-oriented. The workshop setting enables the examination of perceptual and evaluative patterns underlying sustainability design choices. This approach is particularly suited to studying sustainability affordances and trade-offs that are difficult to observe in real-world usage contexts, where such features are often implicit or overshadowed by established routines.

4.1. Empirical Context: The Prototyping Sustainability Workshops

The empirical foundation of this study is the Prototyping Sustainability—Designing Sustainable IT (ProS) workshop series, which provides a participatory and reflective context for exploring digital sustainability [58]. Designed within the InNoWest (<https://innowest-brandenburg.de/> (accessed on 15 May 2026)) project at the Brandenburg University of Applied Sciences, the workshops combine creative prototyping with structured evaluation activities, enabling the observation of how sustainability affordances are articulated, perceived, and discussed.

4.1.1. Setting and Participants

Empirical data were collected through the ProS workshop series conducted between 2024 and 2025 at the Brandenburg University of Applied Sciences with partnering secondary schools in Brandenburg. Adolescents were selected deliberately, as they represent future users and consumers whose perceptions and evaluative reasoning provide early insight into emerging sustainability expectations and design sensitivities relevant for long-term digital futures [44].

Each standard format workshop hosted approximately 20–25 students (ages 14–18, grades 8–12), resulting in roughly 360 participants across 18 regular implementations. The classes were intentionally having different school types (Gymnasium, Montessori, general secondary school) to represent a range of digital competencies and interests. Participants worked in teams of 3–4 students, supported by trained facilitators from the research team. Workshops were conducted in innovation-lab-like settings designed for creative collaboration. Large tables, flexible seating, building blocks, paper, stickers, cut-out kits, markers, and whiteboards were used to support ideation and prototyping. In addition to the standard format, several shorter or adapted formats were piloted during public events. Only the 18 standard workshops were included in the analysis to ensure structural comparability.

4.1.2. Workshop Design and Process

The workshop concept followed a structured, five-phase format that integrates experiential learning, participatory design, and sustainability reflection. Each session lasted a full day (approximately six hours):

Phase 1—Activation and self-reflection: Activities surface prior experiences and intuitive associations with sustainability and digital technologies establishing shared awareness.

Phase 2—Interactive knowledge input: Facilitators introduce key concepts of digital sustainability including three sustainability dimensions (economic, environmental, and social) [24].

Phase 3—Collaborative design and prototyping: Teams develop prototype concepts of apps, websites, or smartphones using cut-out kits, paper, and markers. This phase yields prototype concepts for analysis.

Phase 4—Presentation and peer voting: Teams pitch prototypes; peers complete structured evaluation sheets with a simulated buying decision (as an evaluative judgment) and written rationale. These simulated buying decisions are treated analytically as evaluative judgments that reveal perceived affordance salience rather than as indicators of actual purchase behavior. This produces the second dataset. Accordingly, the term simulated buying decision refers exclusively to the workshop instrument. All analytical discussions use evaluative judgment, with outcomes labeled positive or negative accordingly.

Phase 5—Reflection and learning outcomes: Participants reflect on tensions between sustainability and competing design cues.

Across all phases, the workshop design enables participants to move between intuitive, cognitive, and creative modes of engagement.

4.2. Data Sources and Preparation

Data collection focused on Phase 3 (prototype creation) and Phase 4 (peer evaluation). The analysis draws on two complementary datasets (Table 1). The prototype concepts represented three types of digital product concepts: approximately 50 smartphone concepts, 35 mobile application concepts, and 24 website concepts (109 in total). As the study focused on affordance patterns across prototype concepts, product type was included only as descriptive background information and was not analyzed as a separate variable.

Although the collected prototype concepts included visual elements such as sketches, layouts, and interface representations, the analysis focused primarily on the design cues, functionalities, and sustainability-related concepts communicated through textual annotations, labels, and accompanying descriptions. Visual design characteristics such as color schemes, aesthetic style, or interface composition were not systematically coded. The visual artifacts were used to support the interpretation of prototype concepts but did not constitute a separate unit of analysis.

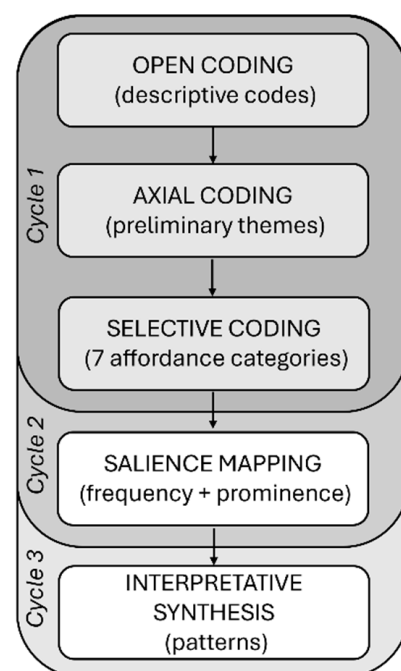
Table 1. Data sources.

Dataset	Description	Quantity
Prototype concepts	Scanned presentation templates including sketches and textual descriptions of features, implementation, and sustainability principles used in design	109
Evaluation sheets	Peer voting templates containing simulated buying decision as well as the corresponding rationale behind it	374

All materials were anonymized, digitized, and imported into MAXQDA 2024 for qualitative analysis. Each workshop and prototype concept received a unique name and ID. Because prototype concepts and evaluation sheets were collected anonymously, evaluators could not be identified. The prototype concept dataset represents design intentions, i.e., how participants expressed sustainability in prototype concepts, and the evaluation sheet dataset captures perceived salience, i.e., how peers recognized and valued those features when making evaluative judgments.

4.3. Analytical Strategy

The analytical process (see Figure 1 for an overview) followed a three-stage cycle consistent with the theoretical propositions related to affordance competition in Section 3.3.

**Figure 1.** Coding process diagram.

Cycle 1—Open, axial, and selective coding

Cycle 1 focused on identifying the references to affordances across the two datasets. Open coding constituted the first analytic step in which prototype descriptions and evaluation comments were broken into small, meaningful units and labeled with descriptive codes that remained close to participants' language [59,60]. This step captured all relevant design cues such as technical, functional, aesthetic, and sustainability without imposing predefined categories. The second step, axial coding, involved grouping these descriptive codes into inductively emerging preliminary themes, such as environmental, social, and economic sustainability aspects, hedonic design characteristics, and indicators of novelty

or innovation. These themes represent intermediate interpretive clusters, not the final analytical categories. Table 2 illustrates a short excerpt of these preliminary clusters. In a third step, selective coding, the preliminary themes were consolidated into the seven affordance categories (sustainability, performance/technical, functional, hedonic/aesthetic, innovation, social/identity, economic/pragmatic) that are presented in Section 5. This final step anchored the inductive patterns in a theoretically informed affordance lens while remaining grounded in participants' language. While the initial coding stages were inductive, the final consolidation of themes into affordance categories was informed by the theoretical lens adopted in this study. The analysis therefore followed an abductive logic in which empirically emerging patterns were iteratively interpreted and refined through engagement with affordance theory. The resulting categories should thus be understood as theoretically informed interpretations of recurring empirical patterns. Within this process, a crucial analytical distinction concerned the relationship between features and affordances. Prototype concepts contain product features (e.g., "solar charging", "repair service"), whereas the evaluation sheets reveal the affordances participants perceived from these features (e.g., energy efficiency, repairability). Both types of statements were coded, and during axial and selective coding, feature-level expressions were abstracted into seven affordance categories.

Table 2. Extract of preliminary themes from axial coding (illustrative snippet).

Preliminary Theme (Axial Coding Stage)	Example Codes	Illustrative Phrases
Environmental sustainability	energy saving, recycling, eco-mode	"charging process", "low energy consumption", "much recycled", "you can give it back", "sleep mode", "dark mode"
Social sustainability	data privacy, working conditions	"no data storage", "anonymous", "fair working conditions", "no slavery obvious"
Economic sustainability	durability, repairability, transparency	"long lasting", "stable", "robust", "easy to repair", "self-repair", "options to repair", "transparency for customers"
Hedonic/aesthetic	gamification, fun, appearance	"learn together", "learn with music", "learn and do sports", "good interface", "modern design", "clearness"
Innovation	idea, timeliness	"awesome idea", "modern" "transformation", "creative innovative idea", "advantage"

The codebook was iteratively refined through coder discussions. Inter-coder reliability indicated strong agreement across categories, achieving a Cohen's kappa of $\kappa = 0.83$ [61].

Cycle 2—Salience mapping

The second analytic cycle focused on assessing the relative salience of different affordances. After translating the initial feature-level codes into the affordance categories (Cycle 1), we examined how frequently each affordance type appeared across both prototype descriptions and evaluation texts. Frequency counts were generated directly from the coded segments in MAXQDA.

Because automated n-gram combinations in MAXDictio did not produce conceptually meaningful patterns for this dataset, salience was assessed through simple frequency patterns and through the degree of emphasis participants placed on particular affordances in their descriptions (e.g., repeated mentions or emphasis markers such as "important," "useful," "cool," "fast").

Salience therefore did not refer to affective valence, but to the perceptual prominence of affordances in participants' language. The output of this cycle was a comparative overview of affordance prominence across the dataset, which then served as input for the interpretive synthesis in Cycle 3.

The analysis does not directly measure cognitive attention, psychological salience, or decision priorities. The frequency and distribution of affordance references are interpreted as indicators of the relative prominence of different affordance categories within participants' prototype descriptions and evaluation statements. Accordingly, the findings should be understood as reflecting patterns of affordance articulation and evaluative emphasis.

Cycle 3—Interpretative synthesis

Cycle 3 moved beyond coding to examine how the previously identified affordances shaped participants' evaluative reasoning. Using the affordance categories developed in Cycle 1 as an analytical frame, we compared justifications across positive, negative, and ambivalent decisions to identify recurring reasoning patterns. This step did not generate new codes; instead, it analyzed the distribution and argumentative use of affordances across evaluations. The synthesis focused on (a) which affordances participants mobilized when justifying positive or negative evaluation, (b) how different affordances were foregrounded or backgrounded, and (c) how these tendencies aligned with the theoretical propositions on salience and affordance competition.

This interpretive step thus connected the coded affordance structure to the evaluation logic expressed by participants, providing a basis for the thematic patterns reported in Section 5. While the justification data provided clear empirical grounding for propositions related to perceptual salience and reward dominance (P1–P2), evidence for reflective amplification (P3) was more limited and appeared primarily in isolated statements rather than systematic patterns.

Accordingly, the study aims to generate insight into how sustainability affordances and competing design cues are perceived, interpreted, and prioritized in evaluative contexts, which provides insight into evaluative processes relevant to sustainability-oriented decision-making.

5. Findings

This section presents how participants embedded and interpreted design cues during the workshops and relates the empirical patterns directly to the theoretical propositions on affordance salience and competition developed in Section 3. As outlined in the methodological section (Section 4.3), prototype design cues were analytically interpreted as affordances, i.e., perceived action possibilities, to enable consistent comparison between design expressions and evaluative reasoning. Accordingly, the findings refer to these analytically derived affordances when discussing patterns across prototype concepts and buying decision justifications.

5.1. Identified Affordance Categories

The analysis of the prototype concepts and the peer evaluation datasets revealed a recurring set of affordance types through which participants interpreted the sustainability-oriented designs. Across the 109 prototype concepts and the 374 evaluation sheets, seven affordance categories consistently appeared. These reflect both the design cues embedded in the prototypes and the affordances perceived by peers during the simulated buying decisions. Sustainability affordances refer to possibilities for responsible or resource-efficient action [26,29]. Performance affordances relate to efficiency, low cognitive effort, and effective operation [27,62]. Functional affordances concern concrete task execution and interaction possibilities [27,63]. Hedonic and aesthetic affordances refer to pleasurable and

emotionally rewarding interactions [64,65]. Innovation affordances denote novelty, exploration, and emerging smart capabilities [46,65–67]. Social and identity affordances enable connection, visibility, and self-presentation [68–72]. Economic and pragmatic affordances relate to cost-efficiency, value, and long-term feasibility [62,73,74]. Table 3 synthesizes these affordance categories, their action possibilities, the codes from data, and their interpretive meaning for this study.

Table 3. Affordance categories identified across prototype concepts and evaluation statements.

Affordance Category	Action Possibility	Data Codes	Interpretation
1. Sustainability Affordances	enable responsible, resource-efficient, ethical action	energy efficiency; renewable energy; CO ₂ -neutral production; ethics, labor conditions; recycled materials; modularity/repair; data minimization; regional production; health-related sustainability	affords acting sustainably, choosing responsible options, reducing impact
2. Performance Affordances	allow fast, efficient, low-effort use	loading speed; processor; reliability; system stability; storage; battery; offline mode; efficient UI; hosting/infrastructure; compatibility	affords efficiency, reduced effort, speed
3. Functional Affordances	enable concrete operations and interactions	calls, chats, video; feedback; notifications; configuration options; sensors; camera; dark/light mode; autoplay; connectivity	affords communication, navigation, personalization, task completion
4. Hedonic/Aesthetic Affordances	enable pleasure, enjoyment, emotional resonance	cool design; simple design; beautiful graphics; entertainment content; recipes; creative content; fun; attractiveness; sound quality	affords pleasure, visual/emotional satisfaction
5. Innovation Affordances	enable novelty, new experiences, technological surprise	originality; innovation; timeliness; uniqueness; AI features; “smart” functions	affords exploration, novel experience, feeling up-to-date
6. Social/Identity Affordances	enable social connection or identity expression	partnerships; social interactions; target-group fit; content for groups; community; profile functions	affords belonging, representation, connection
7. Economic/Pragmatic Affordances	enable practical, cost-efficient, long-term use	price; packaging; durability; warranty; feasibility; material quality; accessibility; transport costs	affords saving money, pragmatic decision-making

While sustainability affordances encompass environmental, social, and economic aspects, these dimensions were aggregated into a single category for the purposes of this study. The objective was not to compare different sustainability dimensions with one another, but to examine how sustainability affordances as a broader category compete with other affordance types in evaluative contexts. Future research could investigate potential differences between environmental, social, and economic sustainability affordances in greater detail.

The next step examines how frequently each affordance type appears across the dataset to understand which cues become salient in different cognitive and evaluative contexts.

5.2. Salience of Affordance Types Across the Dataset

A total of 7607 coded segments were analyzed, to which 8548 affordance codes were assigned. Across the 109 prototype concepts and their associated evaluation materials, this corresponds to an average of approximately 70 coded segments and 78 affordance

codes per concept. Because multiple affordances could be attributed to single segments, the number of affordance codes exceeds the number of textual units. This reflects the multidimensionality of participants' interpretations, where a single feature or justification often invoked several action possibilities.

Across the full dataset, sustainability affordances constitute the largest category (30%), followed by functional (19%), performance/technical (18%), and hedonic/aesthetic affordances (13%). Social/identity and economic/pragmatic affordances each represent 9%, and innovation affordances remain marginal (2%) (see Figure 2). The aggregate distribution demonstrates that, despite the workshop's focus on sustainability, participants addressed a broad spectrum of competing affordances when interpreting digital products.

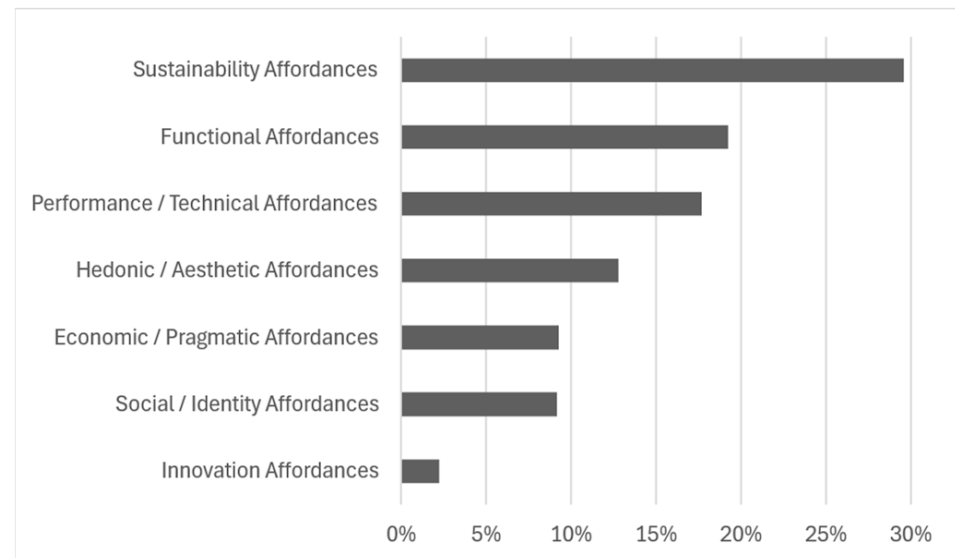


Figure 2. Distribution of affordance types ($n = 8548$ codes).

However, these overall proportions reveal strong context dependencies. Sustainability affordances dominate the prototype concepts (58% of all sustainability-related codes) but remain secondary in positive evaluative judgements (32%) and almost absent in negative evaluative judgements (10%) (see Figure 3). Conversely, functional and performance affordances dominate positive evaluations but appear less prominently in prototypes. These patterns reveal that affordance salience is not intrinsic to particular design cues but is shaped by the cognitive mode of engagement, i.e., whether participants were evaluating existing products or designing new ones. Thus, the proportions reflect the relative frequency of each affordance category across the three datasets (prototype concepts, positive evaluations, and negative evaluations), illustrating strong task-dependent variation in affordance salience. This context-dependent shift directly reflects the perceptual salience disadvantage of sustainability affordances proposed in P1: while sustainability design cues are highly salient in reflective design tasks, they lose prominence in evaluative decision contexts where functional and performance cues dominate attention.

While Figure 3 presents the relative distribution of affordance categories across positive evaluations, negative evaluations, and prototype concepts, Table 4 reports the corresponding absolute frequencies.

To address the contextual effects presented in Figure 3 and Table 4, the following subsections examine how affordance salience differs between positive simulated buying decisions, negative simulated buying decisions, and prototype concepts, beginning with the positive evaluative judgements, i.e., the declaration by the participants of their willingness to potentially buy the designed digital product.

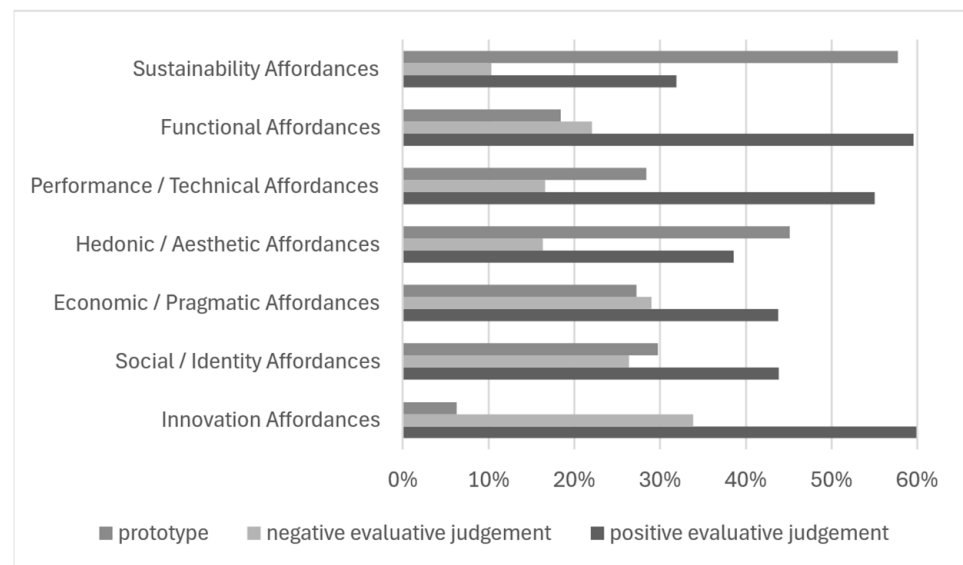


Figure 3. Affordance salience across the three evaluative contexts (“prototype”, “negative evaluative judgement”, “positive evaluative judgement”) within each affordance category.

Table 4. Absolute frequencies underlying Figure 3.

Affordance Category	Positive Evaluative Judgements	Negative Evaluative Judgements	Prototype Concepts	Total
Sustainability Affordances	807	261	1461	2529
Functional Affordances	980	363	303	1646
Performance/Technical Affordances	832	251	429	1512
Hedonic/Aesthetic Affordances	421	178	493	1092
Economic/Pragmatic Affordances	347	230	216	793
Social/Identity Affordances	344	207	233	784
Innovation Affordances	115	65	12	192

5.3. Simulated Buying Decisions: Justifications for “Positive Evaluative Judgements”

The positive evaluation dataset (3656 coded segments and 3846 affordance codes) shows a coherent evaluative pattern in which positive simulated buying decisions are grounded primarily in instrumental and sustainability-oriented affordances, supplemented by experiential qualities. Functional affordances, i.e., clarity, usability, and task effectiveness, constitute the largest share of positive evaluative judgements-related reasoning (25%), indicating that participants tended to evaluate products positively when they perceived them as easy to use and operationally reliable. Performance and technical affordances follow closely (22%), reinforcing the importance of efficiency, responsiveness, and technical smoothness as key conditions for choosing existing digital products.

Sustainability affordances represent a substantial proportion of positive evaluative judgements (21%), suggesting that sustainability considerations play a meaningful, though not dominant, role in positive decisions. Participants frequently acknowledged environmentally or socially responsible features as desirable attributes, but these considerations do not yet overcome the instrumental foundation of their evaluative logic. These findings suggest that sustainability affordances do not hinder participants’ willingness to evaluate a product positively. Rather, they function as supportive attributes that strengthen positive evaluations when core functional expectations are satisfied.

Hedonic and aesthetic affordances account for 11% of positive evaluative judgements codes. While participants appreciated visually appealing, enjoyable, or emotionally resonant designs/content, these qualities primarily strengthen rather than drive the evalua-

tion. Economic/pragmatic and social/identity affordances (each 9%) appear as additional, lower-frequency justification layers. Participants occasionally highlighted value for money, perceived fairness, or target-group fit when supporting existing products, but such considerations were secondary to the primary instrumental and sustainability-oriented evaluations. Innovation affordances remain least influential (3%) and do not play a significant role in affirmative decision-making.

Overall, positive simulated buying decisions reveal an instrumentally anchored evaluative structure in which functional and performance affordances dominate perceived desirability, while sustainability affordances operate as supportive but secondary considerations. Hedonic, social, economic, and innovative dimensions further complement these judgments but rarely function as primary drivers of positive evaluation. This pattern supports Proposition P2, indicating that affordances associated with immediate functional efficiency and experiential reward systematically dominate evaluative reasoning, while sustainability affordances operate primarily as supportive rather than decisive criteria. To understand how participants address affordances in rejecting digital products, the next subsection examines the negative evaluative judgements, i.e., the declaration by the participants of not potentially buying the designed product, and whether they follow similar or contrasting evaluative logics.

5.4. Simulated Buying Decisions: Justifications for “Negative Evaluative Judgements”

The negative evaluative judgements dataset (1385 coded segments and 1555 affordance codes) presents a more diffuse and multidimensional evaluative structure than the positive evaluative judgements dataset. Although functional considerations again play a central role, constituting 23% of all negative evaluation-related affordances, the pattern of negative evaluations reflects a broader constellation of concerns. Participants frequently rejected products due to unclear operation, perceived unreliability, or a lack of intuitive interaction, suggesting that functional shortcomings have a stronger influence on negative than on positive evaluative judgements.

Sustainability affordances represent 17% of negative evaluation-related codes. While this is lower than the proportion found in the positive evaluative judgements dataset (21%), sustainability concerns nonetheless play a notable role in negative evaluations. Participants often pointed to shortcomings related to environmental responsibility, ethical issues, or resource use when they already perceived a product as problematic. Sustainability-related concerns contributed to negative evaluative judgements in two ways: participants criticized products either for insufficient or ethically unclear sustainability practices (e.g., working conditions, data handling) or for sustainability design cues perceived as unrealistic or unworkable (e.g., solar charging). Sustainability thus functioned primarily as a secondary reinforcing dimension that intensified negative evaluative judgements once instrumental or pragmatic concerns were already present, rather than as an independent trigger of negative judgements.

Economic and pragmatic considerations account for 15% of negative evaluation related reasoning. Participants rejected products they deemed insufficiently durable, overpriced, or lacking in long-term value, underscoring the relevance of perceived feasibility and cost–benefit assessments. Social and identity affordances (13%) similarly shaped negative evaluative judgements when products were perceived as misaligned with personal identity, target-group expectations, or social relevance.

Technical performance and hedonic/aesthetic concerns appear with the following frequency: 16% and 11%, respectively. Performance-related negative evaluative judgements typically referred to products perceived as too slow, unstable, or technologically outdated, whereas hedonic shortcomings involved products viewed as unattractive, uninteresting,

or insufficiently engaging. Innovation affordances remain the least frequent negative evaluation trigger (4%), suggesting that a perceived lack of novelty rarely acts as a sufficient reason for rejecting a product on its own.

Taken together, negative evaluative judgements exhibit a less concentrated and more distributed evaluative logic than positive ones. Rather than being shaped by a single dominant criterion, negative evaluative judgements arise from overlapping issues across functional, sustainability, performance, economic, social, and hedonic dimensions. This broader evaluative mix suggests that participants identify multiple forms of misalignment between a product solution and their expectations before deciding against it.

5.5. Cross-Context Affordance Competition

Integrating the affordance patterns across the three datasets reveals how participants' evaluation logic shifts depending on whether they are assessing existing digital products or designing new ones. These shifts underscore that affordances do not hold stable perceptual weight. Rather, they compete for salience depending on the cognitive mode in which participants engage with digital products. The conceptual structure of this competition is visualized in Figure 4. The figure synthesizes dominant affordance patterns across contexts.

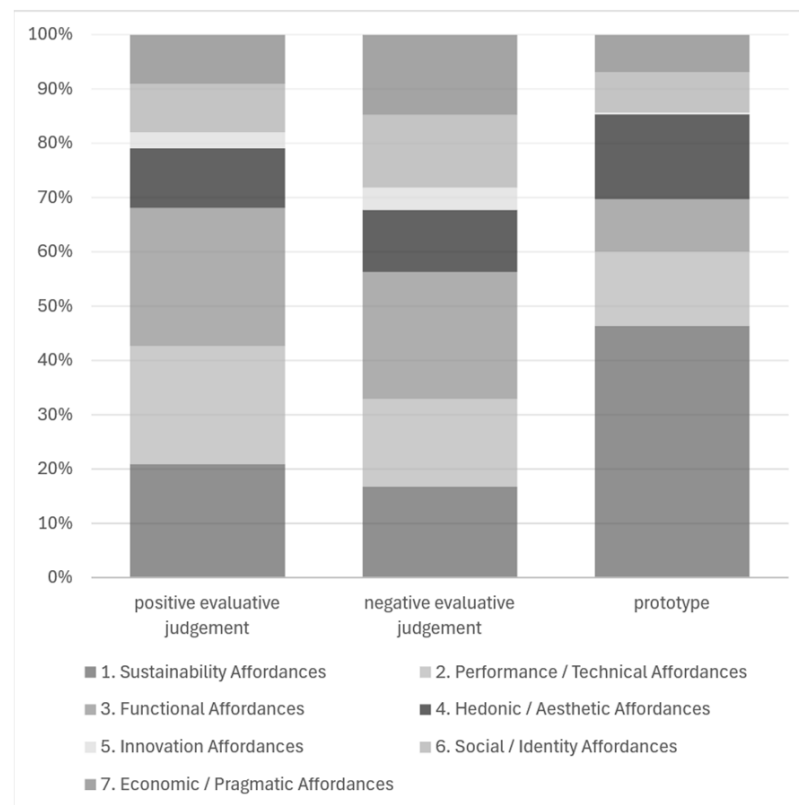


Figure 4. Conceptual affordance competition map.

In design-oriented prototype work, sustainability affordances rise to the forefront and become the primary organizing principle of participants' conceptual reasoning. The higher presence of sustainability affordances in the prototype dataset reflects the sustainability-oriented design cues participants chose to include. These affordances are not designed directly but emerge through the analytical interpretation of those design cues.

Further analysis of positive evaluative judgements shows that they are structured by a more balanced instrumental–sustainability logic, in which functional, performance, and sustainability affordances jointly support perceived desirability. Negative evaluative judgements, however, exhibit the most heterogeneous structure: participants draw on a

broad mix of functional, sustainability, performance, economic, and social affordances when explaining why a product does not meet their expectations. These differences confirm that prototype design and product evaluation activate distinct cognitive modes: reflective and value-oriented in design, instrumental and experience-oriented in evaluation. While moments of reflective engagement in the workshop context occasionally heightened attention to sustainability affordances, such amplification remained situational and did not consistently override instrumental evaluation patterns, providing only limited empirical support for Proposition P3.

Together, these patterns illustrate that affordance salience seems to be strongly context-dependent. Sustainability has been shown to dominate reflective and imaginative design tasks, but becomes one influential dimension among several in everyday evaluative contexts. Positive decisions rely on alignment with instrumental and sustainability cues, whereas negative decisions arise from accumulated misalignments across multiple affordance types. These patterns are consistent with the notion of affordance competition: sustainability affordances dominate reflective and imaginative design contexts but systematically lose salience in evaluative decision-making when competing with immediately rewarding functional and experiential cues. This dynamic may help explain why sustainability-oriented design cues, although cognitively available and valued in principle, rarely become decisive in evaluative judgments of digital product concepts.

6. Discussion

This section discusses the findings in light of the research question, i.e., How do digital product design cues influence the way users evaluate and prioritize sustainability in decision-making contexts?, and connects them to the theoretical propositions and situates them within broader research on sustainable digital futures, design for sustainability, and affordance competition.

6.1. Integrating Findings with the Theoretical Propositions

This study set out to understand how young users perceive, prioritize, and evaluate sustainability design cues when confronted with competing affordances in digital product concepts. By analyzing both prototype design cues and evaluative justifications, the findings illuminate how sustainability affordances compete with functional, performance, and hedonic cues and how these competitions shape evaluative reasoning. Taken together, the results provide substantial support for the first two propositions and more limited support for the third.

P1—Perceptual salience disadvantage of sustainability affordances: The findings strongly support P1. While sustainability considerations dominated the prototype concepts, this pattern should be interpreted in light of the explicit framing of the design task and the sustainability-focused workshop context. Participants received an introduction to digital sustainability and were specifically asked to develop sustainability-oriented digital products. Consequently, the prominence of sustainability affordances in the prototype dataset cannot be interpreted as a direct reflection of spontaneous user preferences. Rather, it reflects the salience of sustainability considerations within a deliberately sustainability-oriented design setting. However, this contextual influence makes the subsequent evaluation results particularly noteworthy. Despite sustainability being strongly foregrounded during the design process, sustainability affordances became far less prominent when participants shifted into evaluative mode. In positive evaluative judgements, sustainability affordances formed a meaningful but secondary layer of reasoning, and in negative evaluative judgements they appeared only marginally. Functional and performance affordances, by contrast, were highly salient across evaluative contexts.

This perceptual asymmetry aligns with the proposition that sustainability affordances face a salience disadvantage in fast, experience-driven evaluations. Prior HCI research on visual prominence and attentional bias similarly demonstrates that sustainability cues often lose perceptual competition to more intuitive or emotionally rewarding cues such as speed, usability, or aesthetics [31,55]. The results therefore confirm that sustainability affordances require active foregrounding to be noticed in ordinary evaluative settings.

P2—Dominance of immediate functional and hedonic rewards: The findings also offer support for P2. Across positive evaluative judgements, participants consistently prioritized affordances associated with immediate functional or performance-related experiential rewards over sustainability affordances. Even when sustainability was acknowledged as desirable, it was rarely decisive for positive evaluative judgements. This pattern indicates that motivational competition systematically favors affordances offering immediate payoff over more abstract or delayed sustainability benefits.

This dynamic is consistent with prior behavioral research suggesting that immediate convenience cues can override sustainability intentions, even among individuals expressing strong pro-environmental attitudes [14,16]. It also resonates with theoretical models of affordance competition, which argue that affordances associated with stronger reward signals gain activation priority in the decision field [30]. Digital nudging research similarly shows that design cues highlighting convenience or pleasure bias evaluative reasoning toward those options [31].

Together, these insights reinforce that sustainability affordances are not rejected by default but are consistently outcompeted by affordances promising immediate functional value.

P3—Reflective amplification in participatory contexts: Support for P3 is more nuanced. During prototype design, participants embedded far more sustainability features than they later emphasized in their evaluative judgements. This suggests that reflective and imaginative design activities momentarily elevate the perceived relevance of sustainability affordances. Participatory design provides cognitive and social support activities such as discussion, co-creation, and peer comparison that can foreground sustainability and enrich its interpretive meaning. However, the evaluation sheets show only limited evidence that this reflective salience persists when participants adopt the role of consumers. Sustainability affordances remained secondary in positive evaluative judgements (after functional and performance affordances) and highly fragmented in negative evaluative judgements. Thus, while participatory design tasks can amplify sustainability considerations during creation, this amplification does not automatically translate into evaluative behavior.

This finding aligns with value-sensitive design and transformative learning research, which suggests that reflective engagement can broaden value awareness but may require stronger structural or contextual support to shift everyday decision patterns [40,57]. Future research could examine the specific reflective conditions under which such salience shifts become more stable and whether they translate into actual behavioral outcomes.

While these findings provide insight into how participants perceived and prioritized competing affordances, they should be interpreted in light of the nature of the empirical material. Participants evaluated conceptual prototype representations and written descriptions rather than fully functional digital products. Consequently, the results reflect perceived affordance salience and evaluative reasoning under hypothetical conditions rather than observed behavior in real-world usage contexts. The study therefore offers insight into how sustainability design cues are interpreted and discussed, but does not allow direct conclusions about actual adoption, usage, or purchasing behavior. Future research could examine whether similar affordance competition patterns emerge when users interact with functioning digital systems or make real consumption decisions.

In combination, these findings refine the affordance-competition explanation of how sustainability affordances and competing affordances are prioritized during the evaluation of digital product concepts. Sustainability affordances face both perceptual (P1) and motivational (P2) disadvantages, which limit their influence in evaluative contexts. Participatory environments can temporarily boost their salience (P3), but this effect remains fragile and uneven. These insights form the conceptual basis for deriving design strategies intended to strengthen the usability, visibility, and desirability of sustainability affordances.

6.2. Implications for Design and Digital Sustainability

The findings provide insights into how sustainability affordances and competing affordances were articulated and evaluated by participants. When interpreted alongside established research on sustainable interaction design [75], sustainable HCI [14,15], digital nudging [31], and sustainability-oriented Information Systems [46], several implications for digital product design emerge.

- (1) **Sustainability per default:** Participants prioritized minimal effort and clarity in their positive evaluative judgements (codes “easy operation”, “simple, user-friendly design”). Prior research suggests that default settings can effectively support sustainability-oriented decisions by reducing the effort required to select environmentally preferable option [76]. Integrating sustainability settings, such as energy-saving modes enabled by default, automatic activation of dark mode, or default restrictions on unnecessary data collection, may therefore increase their visibility and relevance in digital products.
- (2) **Cognitive effort and friction reduction:** At the same time, negative evaluative judgements reflected functional or usability concerns (codes “complex operation”, “complex design”). Consistent with digital nudging research [31,77], minimizing the effort required to access sustainability features, for example, one-click repair information or simplified battery optimization settings, may help reduce potential barriers to their consideration.
- (3) **Increasing the visibility of sustainability affordances:** Sustainability affordances appeared less prominently in evaluation contexts than functional or performance affordances. Prior research suggests that visibility and interface prominence influence how users interpret and evaluate digital features [52,55]. Making sustainability-related information more noticeable, for example, through displaying energy consumption indicators next to battery information, highlighting repairability scores, or making sustainability labels visible during configuration choices, may therefore increase its presence in evaluative processes.
- (4) **Sustainability links to hedonic or emotional value:** Participants frequently valued attractiveness, enjoyment, and engaging user experiences. Sustainable HCI research suggests that sustainability features may become more appealing when linked to positive emotional experiences rather than being framed solely as constraints or sacrifices [15,34], for example, gamified sustainability achievements, visual progress indicators, or creative challenges linked to sustainable digital practices.
- (5) **Immediate sustainability feedback:** Feedback and notifications (codes “feedback”, “notifications”) were appreciated by the young consumers and highlighted in their positive evaluative judgements correspondingly. Research on eco-feedback systems indicates that timely information about resource consumption or sustainability impacts can support sustainability-oriented reflection and awareness [78]. Providing immediate feedback, for instance, “you saved 12% more energy today”, may therefore increase the perceived relevance of sustainability design cues.

- (6) Embedding sustainability into core functionality: The findings indicate that participants often focused on functional qualities when evaluating digital products. Consistent with sustainable design research, sustainability affordances, such as battery optimization, data minimization, or device longevity features, may therefore be more effective when integrated into core functionality (primary system settings) rather than presented as optional or peripheral features [46,79].

Together, these implications suggest that sustainability affordances may become more visible and relevant when they are integrated into core user experiences, supported by low-friction interaction patterns, and aligned with established principles from sustainable digital design research.

6.3. Theoretical Contributions and Directions for Future Research

This study contributes to research on digital sustainability and sustainability-oriented design by providing empirical insights into how sustainability affordances and competing affordances are perceived, prioritized, and evaluated in digital product contexts. Drawing on an affordance-based perspective, the findings illuminate how affordance salience varies across design and evaluation activities and how sustainability considerations are articulated and negotiated in participatory settings. Together, these contributions advance understanding of how sustainability design features are interpreted in relation to competing design priorities and how such interpretations vary across contexts.

Contribution 1: Empirical evidence on sustainability affordances and competing affordances in digital product contexts. While previous research has highlighted the importance of sustainability-oriented design features [14,16,29], relatively little empirical evidence exists on how such features are perceived in relation to competing affordances during evaluative processes. By analyzing both prototype concepts and peer evaluation statements, this study provides empirical evidence that sustainability affordances coexist with functional, performance, hedonic, social, economic, and innovation affordances, but are not prioritized equally across contexts. Sustainability affordances were particularly prominent during prototype creation, whereas functional and performance affordances became more salient during evaluative judgments. These findings contribute to a more nuanced understanding of how different affordance categories are prioritized when users engage with sustainability-oriented digital product concepts.

Contribution 2: An affordance-based perspective on context-dependent affordance salience. The study further demonstrates the usefulness of an affordance-based perspective for interpreting context-dependent shifts in affordance salience. Building on affordance theory [25,27,45] and affordance competition and digital nudging perspectives [30,31], the findings suggest that affordances do not possess fixed levels of relevance or visibility. Rather, their salience depends on the context in which users engage with digital product concepts. The comparison between prototype concept creation and evaluative judgments illustrates how different affordances become more or less prominent depending on task framing and interpretive orientation. In this sense, the study demonstrates the usefulness of affordance competition as an interpretive lens for understanding why sustainability affordances and competing affordances are prioritized differently across contexts. The findings thereby contribute to Information Systems and HCI research by highlighting the contextual and dynamic nature of affordance salience in sustainability-oriented digital design settings.

Contribution 3: Participatory design as a context for examining sustainability affordances. Participatory design (PD), long recognized for its capacity to support inclusive and value-oriented design processes [80–82], is shown here to provide a valuable context for examining how sustainability considerations are articulated, negotiated, and

evaluated among young users. In the ProS workshops, participants engaged both in creating sustainability-oriented digital product concepts and in evaluating peer-generated ideas. This dual role generates insights into how sustainability features gain meaning during reflective design activities and how their perceived relevance changes when participants adopt an evaluative perspective. The findings therefore contribute to research at the intersection of participatory design and sustainability [42,70] by illustrating both the potential and limitations of participatory reflection as a means of foregrounding sustainability considerations.

Taken together, these contributions provide a user-centered perspective on the sustainability–digitalization paradox [3–5]. While prior research has primarily examined this paradox at organizational and systemic levels, the present study illustrates how tensions between sustainability considerations and competing design priorities become visible in everyday evaluative contexts. The findings suggest that shifts in affordance salience across contexts may also play an important role in shaping how sustainability considerations are evaluated in digital product settings.

The findings open several promising directions for future research on digital sustainability and affordance-based design. First, controlled experiments could systematically test how manipulating affordance salience, for instance, through default settings, visual prominence, or friction reduction, influences evaluative judgments. Such studies could further investigate the context-dependent patterns identified in this study. Second, longitudinal research is needed to assess the durability of the reflective amplification observed in participatory contexts. Understanding whether and how reflective design activities influence longer-term evaluations and preferences would deepen knowledge of sustainability-oriented value formation in digital environments. Third, comparative studies across demographic or cultural groups could reveal how affordance hierarchies differ across age, expertise, or societal contexts. Adolescents represent an important user segment, but adults, professionals, or low-digital-literacy groups may prioritize affordances differently. Fourth, future research could explore how affordance-based perspectives relate to complementary theoretical approaches such as dual-process theories [71,72], habit formation models [83,84], and digital nudging frameworks [31]. Finally, future work should investigate affordance landscapes in commercial digital platforms to examine how sustainability affordances and competing affordances are presented, prioritized, or obscured through design choices. Such analyses could provide practical guidance for identifying design patterns that support or hinder sustainability-oriented evaluations, including the role of dark-pattern strategies in shaping user attention and decision-making [85,86].

7. Conclusions

This study examined how young users perceive and prioritize sustainability affordances and competing affordances in digital product contexts. By analyzing 109 prototype concepts and 374 evaluation statements from participatory design workshops, the findings show that sustainability affordances are widely embedded in design ideas but systematically lose salience when participants engage in evaluative decision-making. While reflective prototype creation foregrounded sustainability as a central organizing principle, evaluative judgements were guided primarily by functional and performance affordances, with sustainability operating as an important but secondary criterion rather than a decisive driver. Negative evaluative judgements exhibited the most heterogeneous evaluative patterns, indicating that multiple forms of misalignment typically accumulate before a digital product concept is dismissed.

Beyond the relative importance of specific affordance categories, the findings highlight the contextual nature of affordance salience. The participants emphasized different affordances depending on whether they were engaged in designing digital product concepts or evaluating them. Sustainability affordances were particularly prominent during reflective design activities, whereas functional and performance affordances became more salient during evaluative judgments. This suggests that affordance salience is dynamic rather than fixed and depends on the context in which digital products are considered. The sustainability-value gap may therefore not simply reflect a lack of sustainability awareness but also shifts in which affordances become salient across different contexts. Hence, the findings complement motivational accounts of the sustainability-value gap by identifying a contextual factor: the relative salience of sustainability affordances shifts systematically depending on whether users are creating or evaluating digital products.

Together, these results suggest that sustainability affordances become less prominent in evaluative contexts where participants emphasize functional and performance-related considerations. Interpreted through an affordance competition perspective, the findings indicate that sustainability considerations may receive less attention when evaluated alongside competing design priorities. At the same time, the findings highlight the potential role of digital design in supporting sustainability-oriented evaluations and decision-making: when sustainability features are made visible, seamlessly integrated, and aligned with users' core functional expectations, they can increase the visibility and perceived relevance of sustainability considerations in evaluative decision contexts rather than relying solely on conscious sacrifice or moral motivation.

While the findings are based on conceptual prototype representations and evaluative judgements rather than interactions with fully functional digital products, they nevertheless provide valuable insight into how sustainability affordances are perceived, prioritized, and evaluated in relation to competing affordances and design cues.

For research on digital sustainability, the study demonstrates the usefulness of affordance-based and competition-oriented perspectives for interpreting how sustainability affordances and competing affordances are prioritized across different evaluative contexts. For designers and practitioners, it underscores the importance of embedding sustainability affordances in ways that enhance their visibility, immediacy, and integration with core functionality. Future research should examine these affordance dynamics in real-world digital environments and across diverse user groups to assess how design strategies can more effectively translate sustainability-oriented features into sustainable digital practices.

Author Contributions: Conceptualization, O.L., A.R. and F.L.; methodology, O.L., F.L. and A.R.; validation, O.L., F.L. and A.R.; investigation, O.L., F.L. and A.R.; formal analysis, A.R.; data curation, A.R. and F.L.; resources, O.L., F.L. and A.R.; writing—original draft preparation, A.R.; writing—review and editing, O.L. and A.R.; visualization, A.R. and F.L.; supervision, O.L.; project administration, O.L. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by the Federal Ministry of Research, Technology and Space (Bundesministerium für Forschung, Technologie und Raumfahrt) and the Joint Science Conference (Gemeinsame Wissenschaftskonferenz, GWK) under the framework of the Innovative University program (Innovative Hochschule), as part of the “InNoWest–Einfach machen! Gemeinsam nachhaltig und digital in Nord-West-Brandenburg” project under the funding codes 03IHS230A (HNEE), 03IHS230B (FHP), and 03IHS230C (THB).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The original contributions presented in this study are included in the article. Further inquiries can be directed to the corresponding author.

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

References

1. Yoo, Y.; Boland, R.J.; Lyytinen, K.; Majchrzak, A. Organizing for Innovation in the Digitized World. *Organ. Sci.* **2012**, *23*, 1398–1408. [\[CrossRef\]](#)
2. Bibri, S.E. Data-Driven Smart Sustainable Cities of the Future: An Evidence Synthesis Approach to a Comprehensive State-of-the-Art Literature Review. *Sustain. Futures* **2021**, *3*, 100047. [\[CrossRef\]](#)
3. Kotlarsky, J.; Oshri, I.; Sekulic, N. Digital Sustainability in Information Systems Research: Conceptual Foundations and Future Directions. *J. Assoc. Inf. Syst.* **2023**, *24*, 936–952. [\[CrossRef\]](#)
4. Alt, R. Evolution and Perspectives of Electronic Markets. *Electron. Mark.* **2020**, *30*, 1–13. [\[CrossRef\]](#)
5. Veit, D.J.; Thatcher, J.B. Digitalization as a Problem or Solution? Charting the Path for Research on Sustainable Information Systems. *J. Bus. Econ.* **2023**, *93*, 1231–1253. [\[CrossRef\]](#)
6. Jones, N. How to Stop Data Centres from Gobbling up the World’s Electricity. *Nature* **2018**, *561*, 163–166. [\[CrossRef\]](#) [\[PubMed\]](#)
7. Rolnick, D.; Donti, P.L.; Kaack, L.H.; Kochanski, K.; Lacoste, A.; Sankaran, K.; Ross, A.S.; Milojevic-Dupont, N.; Jaques, N.; Waldman-Brown, A.; et al. Tackling Climate Change with Machine Learning. *ACM Comput. Surv.* **2023**, *55*, 1–96. [\[CrossRef\]](#)
8. Vinuesa, R.; Azizpour, H.; Leite, I.; Balaam, M.; Dignum, V.; Domisch, S.; Felländer, A.; Langhans, S.D.; Tegmark, M.; Fuso Nerini, F. The Role of Artificial Intelligence in Achieving the Sustainable Development Goals. *Nat. Commun.* **2020**, *11*, 233. [\[CrossRef\]](#) [\[PubMed\]](#)
9. Schwartz, R.; Dodge, J.; Smith, N.A.; Etzioni, O. Green AI. *Commun. ACM* **2020**, *63*, 54–63. [\[CrossRef\]](#)
10. Strubell, E.; Ganesh, A.; McCallum, A. Energy and Policy Considerations for Deep Learning in NLP. In *Proceedings of the 57th Annual Meeting of the Association for Computational Linguistics*; Korhonen, A., Traum, D., Màrquez, L., Eds.; Association for Computational Linguistics: Florence, Italy, 2019; pp. 3645–3650.
11. Ologeanu-Taddei, R.; Hönigsberg, S.; Weritz, P.; Wache, H.; Mittermeier, F.; Tana, S.; Dang, D.; Hautala-Kankaanpää, T.; Pekkola, S. The Relationship of Digital Transformation and Corporate Sustainability: Synergies and Tensions. *Technol. Forecast. Soc. Change* **2025**, *210*, 123809. [\[CrossRef\]](#)
12. Ryu, S.; Koedijk, K.G.; Chow, V.; Gao, X. Environmental, Social, and Governance (ESG) for Online Marketplaces. *Electron. Mark.* **2024**, *34*, 19. [\[CrossRef\]](#)
13. Lobschat, L.; Mueller, B.; Eggers, F.; Brandimarte, L.; Diefenbach, S.; Kroschke, M.; Wirtz, J. Corporate Digital Responsibility. *J. Bus. Res.* **2021**, *122*, 875–888. [\[CrossRef\]](#)
14. Bemmman, F.; Mayer, S. User-Centered Sustainable Technology Design: A Reflection on Human-Computer Interaction Research for a Sustainable Society. In *Proceedings of the Joint Proceedings of ICT4S 2023 Doctoral Symposium, Demonstrations & Posters Track and Workshops*, Rennes, France, 5–10 June 2023; pp. 99–102.
15. Boll, S.; Väänänen, K.; Bidwell, N.; Hassenzahl, M.; Neuhaus, R. A Human-Computer Interaction Perspective to Drive Change towards Sustainable Future (Dagstuhl Perspectives Workshop 23092). *Dagstuhl Rep.* **2023**, *13*, 199–241. [\[CrossRef\]](#)
16. Renz, E.; Böhm, K.L. Using Behavioral Economics to Reduce the Value-Action Gap. *Ökol. Wirtsch.—Fachz.* **2020**, *33*, 45–50. [\[CrossRef\]](#)
17. Terlau, W.; Hirsch, D. Sustainable Consumption and the Attitude-Behaviour-Gap Phenomenon—Causes and Measurements towards a Sustainable Development. *Int. J. Food Syst. Dyn.* **2015**, *6*, 159–174. [\[CrossRef\]](#)
18. Besana, N.; Krogh, P.G.; Petersen, M.G.; Spallazzo, D. Expanding the Concept of Sustainable Interaction Design: A Systematic Review. *Sustainability* **2024**, *16*, 7486. [\[CrossRef\]](#)
19. Duarte Pobleto, S.S.; Romani, A.; Rognoli, V. Emerging Materials for Transition: A Taxonomy Proposal from a Design Perspective. *Sustain. Futures* **2024**, *7*, 100155. [\[CrossRef\]](#)
20. Duygan, M.; Binder, C.R.; Meylan, G.; Fischer, M. Carving the Transformation Pathways to Sustainable Futures: A Novel Analytical Framework for Backcasting in Sustainability Transitions. *Sustain. Futures* **2025**, *9*, 100553. [\[CrossRef\]](#)
21. Lopes, J.M.; Gomes, S.; Suchek, N.; Nogueira, S. The Hidden Reasons behind Generation Z’s Green Choices. *Discov. Sustain.* **2024**, *5*, 520. [\[CrossRef\]](#)
22. Theocharis, D.; Tsekouropoulos, G. Sustainable Consumption and Branding for Gen Z: How Brand Dimensions Influence Consumer Behavior and Adoption of Newly Launched Technological Products. *Sustainability* **2025**, *17*, 4124. [\[CrossRef\]](#)
23. Xue, Y.; Feng, T.; Wu, C. How Technical and Situational Cues Affect Impulse Buying Behavior in Social Commerce? Evidence from Bored Consumers. *Front. Psychol.* **2024**, *15*, 1405189. [\[CrossRef\]](#) [\[PubMed\]](#)
24. Elkington, J. *Cannibals with Forks: Triple Bottom Line of 21st Century Business*; Capstone Publishing Ltd.: Oxford, UK, 1999.
25. Faraj, S.; Azad, B. The Materiality of Technology: An Affordance Perspective. In *Materiality and Organizing: Social Interaction in a Technological World*; Oxford Academic: Oxford, UK, 2013; pp. 237–258.
26. Gibson, J.J. *The Ecological Approach to Visual Perception*; Houghton, Mifflin and Company: Boston, MA, USA, 1979; pp. 14, 332.

27. Markus, M.; Silver, M. A Foundation for the Study of IT Effects: A New Look at DeSanctis and Poole's Concepts of Structural Features and Spirit. *J. AIS* **2008**, *9*, 609–632. [[CrossRef](#)]
28. Volkoff, O.; Strong, D.M. Affordance Theory and How to Use It in IS Research. In *The Routledge Companion to Management Information Systems*; Routledge: London, UK, 2017.
29. Kaaronen, R.O. Affording Sustainability: Adopting a Theory of Affordances as a Guiding Heuristic for Environmental Policy. *Front. Psychol.* **2017**, *8*, 1974. [[CrossRef](#)] [[PubMed](#)]
30. Cisek, P. Cortical Mechanisms of Action Selection: The Affordance Competition Hypothesis. *Philos. Trans. R. Soc. B Biol. Sci.* **2007**, *362*, 1585–1599. [[CrossRef](#)] [[PubMed](#)]
31. Weinmann, M.; Schneider, C.; vom Brocke, J. Digital Nudging. *Bus. Inf. Syst. Eng.* **2016**, *58*, 433–436. [[CrossRef](#)]
32. Deterding, S.; Dixon, D.; Khaled, R.; Nacke, L. From Game Design Elements to Gamefulness: Defining “Gamification”. In *Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments*; Association for Computing Machinery: New York, NY, USA, 2011; pp. 9–15.
33. Hamari, J.; Koivisto, J.; Sarsa, H. Does Gamification Work?—A Literature Review of Empirical Studies on Gamification. In *Proceedings of the 2014 47th Hawaii International Conference on System Sciences*, Waikoloa, HI, USA, 6–9 January 2014; pp. 3025–3034.
34. Hassenzahl, M. The Thing and I: Understanding the Relationship Between User and Product. In *Funology 2: From Usability to Enjoyment*; Blythe, M., Monk, A., Eds.; Springer International Publishing: Cham, Switzerland, 2003; pp. 301–313.
35. Hassenzahl, M. *Experience Design: Technology for All the Right Reasons*; Morgan & Claypool Publishers: San Rafael, CA, USA, 2010.
36. Smith, W.K.; Lewis, M.W. Toward a Theory of Paradox: A Dynamic Equilibrium Model of Organizing. *Acad. Manag. Rev.* **2011**, *36*, 381–403. [[CrossRef](#)]
37. Belkhir, L.; Elmeligi, A. Assessing ICT Global Emissions Footprint: Trends to 2040 & Recommendations. *J. Clean. Prod.* **2018**, *177*, 448–463. [[CrossRef](#)]
38. Hilty, L.; Aebischer, B. ICT for Sustainability: An Emerging Research Field. In *Advances in Intelligent Systems and Computing*; Springer: Berlin/Heidelberg, Germany, 2015; Volume 310, pp. 3–36.
39. Melville, N.P. Information Systems Innovation for Environmental Sustainability. *MIS Q.* **2010**, *34*, 1–21. [[CrossRef](#)]
40. Sanders, E.B.-N.; Brandt, E.; Binder, T. A Framework for Organizing the Tools and Techniques of Participatory Design. In *Proceedings of the 11th Biennial Participatory Design Conference*; ACM: Sydney, Australia, 2010; pp. 195–198.
41. Peet, E.R.; Mulder, S.; Mulder, I. Co-Design for Transitions: Developing Genuine Participatory Approaches to Involving Lifeworld and System Participants. *CoDesign* **2025**, 1–19. [[CrossRef](#)]
42. Poderi, G.; Dittrich, Y. Participatory Design and Sustainability: A Literature Review of PDC Proceedings. In *Proceedings of the 15th Participatory Design Conference: Short Papers, Situated Actions, Workshops and Tutorial—Volume 2*; Association for Computing Machinery: New York, NY, USA, 2018; pp. 1–5.
43. Weick, K.E. *Sensemaking in Organizations*; SAGE: Thousand Oaks, CA, USA, 1995.
44. Potapov, K.; Ramadan, M. Participatory Design of an Eco-Feedback Tool with Teens for Community Energy Futures. *Int. J. Child-Comput. Interact.* **2026**, *47*, 100802. [[CrossRef](#)]
45. Volkoff, O.; Strong, D.M. Critical Realism and Affordances: Theorizing It-Associated Organizational Change Processes. *MIS Q.* **2013**, *37*, 819–834. [[CrossRef](#)]
46. Seidel, S.; Recker, J.; vom Brocke, J. Sensemaking and Sustainable Practicing: Functional Affordances of Information Systems in Green Transformations. *MIS Q.* **2013**, *37*, 1275–1300. [[CrossRef](#)]
47. Leal Filho, W. (Ed.) *Aktuelle Ansätze zur Umsetzung der UN-Nachhaltigkeitsziele*; Springer: Berlin/Heidelberg, Germany, 2019.
48. Bocken, N.M.P.; de Pauw, I.; Bakker, C.; van der Grinten, B. Product Design and Business Model Strategies for a Circular Economy. *J. Ind. Prod. Eng.* **2016**, *33*, 308–320. [[CrossRef](#)]
49. Erickson, T.; Li, M.; Kim, Y.; Deshpande, A.; Sahu, S.; Chao, T.; Sukaviriya, P.; Naphade, M. The Dubuque Electricity Portal: Evaluation of a City-Scale Residential Electricity Consumption Feedback System. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*; Association for Computing Machinery: New York, NY, USA, 2013; pp. 1203–1212.
50. Trepte, S.; Scharnow, M.; Dienlin, T. The Privacy Calculus Contextualized: The Influence of Affordances. *Comput. Hum. Behav.* **2020**, *104*, 106115. [[CrossRef](#)]
51. Tractinsky, N.; Katz, A.S.; Ikar, D. What Is Beautiful Is Usable. *Interact. Comput.* **2000**, *13*, 127–145. [[CrossRef](#)]
52. Mathur, A.; Acar, G.; Friedman, M.J.; Lucherini, E.; Mayer, J.; Chetty, M.; Narayanan, A. Dark Patterns at Scale: Findings from a Crawl of 11K Shopping Websites. *Proc. ACM Hum.-Comput. Interact.* **2019**, *3*, 1–32. [[CrossRef](#)]
53. Enginkaya, E.; Hayrun Sağlam, M. Navigating Sustainability: The Role of Consumer Psychology in Shaping Sustainable Behavior. *Sage Open* **2025**, *15*, 21582440251376481. [[CrossRef](#)]
54. Grimal, L.; Di Loreto, I.; Troussier, N. Value Misalignments in Interactions: An Opportunity for Sustainable HCI. In *Proceedings of the 34th Conference on l'Interaction Humain-Machine*, Troyes, France, 3–6 April 2023.

55. Djamasbi, S.; Siegel, M.; Tullis, T. Generation Y, Web Design, and Eye Tracking. *Int. J. Hum.-Comput. Stud.* **2010**, *68*, 307–323. [[CrossRef](#)]
56. Kim, Y.S. A Methodology of Design for Affordances Using Affordance Feature Repositories. *AI EDAM* **2015**, *29*, 307–323. [[CrossRef](#)]
57. Mezirow, J. Transformative Learning: Theory to Practice. *New Dir. Adult Contin. Educ.* **1997**, *1997*, 5–12. [[CrossRef](#)]
58. Levina, O.; Lindauer, F.; Revina, A. A Participatory Workshop Design for Engaging Young People in IT Sustainability. *Educ. Sci.* **2025**, *15*, 1570. [[CrossRef](#)]
59. Charmaz, K. *Constructing Grounded Theory*; SAGE: Thousand Oaks, CA, USA, 2014; pp. 1–416.
60. Strauss, A.; Corbin, J. *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory*, 2nd ed.; Sage Publications, Inc.: Thousand Oaks, CA, USA, 1998; pp. 13, 312.
61. Landis, J.R.; Koch, G.G. The Measurement of Observer Agreement for Categorical Data. *Biometrics* **1977**, *33*, 159–174. [[CrossRef](#)]
62. Venkatesh, V.; Morris, M.G.; Davis, G.B.; Davis, F.D. User Acceptance of Information Technology: Toward a Unified View. *MIS Q.* **2003**, *27*, 425–478. [[CrossRef](#)]
63. Norman, D. *The Design of Everyday Things*; Basic Books, Member of the Perseus Books Group: New York, NY, USA, 2013.
64. Hassenzahl, M. *Hedonic, Emotional, and Experiential Perspectives on Product Quality*; Ghaoui, C., Ed.; IGI Global: Hershey, PA, USA, 2006; pp. 266–272.
65. Norman, W.; MacDonald, C. Getting to the Bottom of “Triple Bottom Line”. *Bus. Ethics Q.* **2004**, *14*, 243–262. [[CrossRef](#)]
66. Cho, Y.; Choi, A. Application of Affordance Factors for User-Centered Smart Homes: A Case Study Approach. *Sustainability* **2020**, *12*, 3053. [[CrossRef](#)]
67. Verganti, R. *Design Driven Innovation: Changing the Rules of Competition by Radically Innovating What Things Mean*; Harvard Business Press: Boston, MA, USA, 2009.
68. Boyd, D. Social Network Sites as Networked Publics: Affordances, Dynamics, and Implications. In *A Networked Self*; Routledge: London, UK, 2010.
69. Zhao, S.; Grasmuck, S.; Martin, J. Identity Construction on Facebook: Digital Empowerment in Anchored Relationships. *Comput. Hum. Behav.* **2008**, *24*, 1816–1836. [[CrossRef](#)]
70. Light, A.; Akama, Y. Structuring Future Social Relations. In Proceedings of the PDC '14: Proceedings of the 13th Participatory Design Conference: Research Papers, Windhoek, Namibia, 6–10 October 2014; Volume 1, pp. 151–160. [[CrossRef](#)]
71. Evans, J.S.B.T. Dual-Processing Accounts of Reasoning, Judgment, and Social Cognition. *Annu. Rev. Psychol.* **2008**, *59*, 255–278. [[CrossRef](#)] [[PubMed](#)]
72. Kahneman, D. *Thinking, Fast and Slow*; Penguin: London, UK, 2012.
73. Davis, F.D. Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Q.* **1989**, *13*, 319–340. [[CrossRef](#)] [[PubMed](#)]
74. Zeithaml, V.A. Consumer Perceptions of Price, Quality, and Value: A Means-End Model and Synthesis of Evidence. *J. Mark.* **1988**, *52*, 2–22. [[CrossRef](#)] [[PubMed](#)]
75. Blevis, E. Sustainable Interaction Design: Invention & Disposal, Renewal & Reuse. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*; Association for Computing Machinery: New York, NY, USA, 2007; pp. 503–512.
76. Pichert, D.; Katsikopoulos, K.V. Green Defaults: Information Presentation and pro-Environmental Behaviour. *J. Environ. Psychol.* **2008**, *28*, 63–73. [[CrossRef](#)]
77. Caraban, A.; Karapanos, E.; Gonçalves, D.; Campos, P. 23 Ways to Nudge: A Review of Technology-Mediated Nudging in Human-Computer Interaction. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*; Association for Computing Machinery: New York, NY, USA, 2019; pp. 1–15.
78. Froehlich, J.; Findlater, L.; Landay, J. The Design of Eco-Feedback Technology. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*; Association for Computing Machinery: New York, NY, USA, 2010; pp. 1999–2008.
79. Gujral, H.; Bremer, C.; Perera, D.; Easterbrook, S. Design for Digital Sufficiency: Understanding User Preferences for More Sustainable Data Centers. *ACM J. Comput. Sustain. Soc.* **2025**, *3*, 31:1–31:31. [[CrossRef](#)]
80. Schuler, D.; Namioka, A. (Eds.) *Participatory Design: Principles and Practices*; Lawrence Erlbaum Associates: Hillsdale, NJ, USA, 1993.
81. Sanders, E.B.-N.; Stappers, P.J. Co-Creation and the New Landscapes of Design. *CoDesign* **2008**, *4*, 5–18. [[CrossRef](#)]
82. Spinuzzi, C. The Methodology of Participatory Design. *Tech. Commun.* **2005**, *52*, 163–174.
83. Lally, P.; van Jaarsveld, C.H.M.; Potts, H.W.W.; Wardle, J. How Are Habits Formed: Modelling Habit Formation in the Real World. *Eur. J. Soc. Psychol.* **2010**, *40*, 998–1009. [[CrossRef](#)]
84. Wood, W.; Neal, D.T. A New Look at Habits and the Habit-Goal Interface. *Psychol. Rev.* **2007**, *114*, 843–863. [[CrossRef](#)] [[PubMed](#)]

85. Gray, C.M.; Kou, Y.; Battles, B.; Hoggatt, J.; Toombs, A.L. The Dark (Patterns) Side of UX Design. In Proceedings of the CHI 2018—Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems, Montreal, QC, Canada, 21–26 April 2018. [[CrossRef](#)]
86. Nouwens, M.; Liccardi, I.; Veale, M.; Karger, D.; Kagal, L. Dark Patterns after the GDPR: Scraping Consent Pop-Ups and Demonstrating Their Influence. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*; Association for Computing Machinery: New York, NY, USA, 2020; pp. 1–13.

Disclaimer/Publisher’s Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.